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CONTENTS

On estimating the relation between blood group and disease. B. WOOLF
Blood groups in Jews from Cochin, India. J. GUREVITCH, E. HASSON, E. MARGOLIS & C. POLIAKOFF
Blood groups in Jews from Iraq. J. GUREVITCH & E. MARGOLIS
Blood groups in Jews from Tripolitania. J. GUREVITCH, E. HASSON, E. MARGOLIS & C. POLIAKOFF
Birth weight in cousins. ELIZABETH B. ROBSON
Filter paper electrophoresis of mouse hemoglobin. Preliminary note. HELEN M. RANNEZ & SALOME GLUECKSOHN-WAELSCH
Monozygotic and dizygotic twin diagnosis. L. S. PENROSE & SHEILA MAYNARD SMITH
Taste thresholds for PTC of some population groups. J. W. R. LUGG & J. M. WHYTE
Genetical linkage between the ABO group and the nail-patella locus. SYLVIA D. LAWLER & J. H. RENWICK
Inbreeding with the homozygotes at a disadvantage. E. C. R. REEVE
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Vol. 36, No. 3 — *Table of Contents* — July 1955

Observations on the ecology of a polyhedrosis of the Great Basin tent caterpillar *Malacosoma fragilis* *Edwin C. Clark*
Annual trends in hardiness of ponderosa pine and grand fir *Johnson Parker*
A study of the occurrence of amphibians in relation to a bog succession, Itasca State Park, Minnesota *William H. Marshall and Murray F. Buell*
The climates of South Bass Island, western Lake Erie *James L. Verber*
Studies on moisture relationships in earthworms *William C. Grant, Jr.*
Natural revegetation of a field abandoned for thirty-three years in central Kansas *G. W. Tomanek, F. W. Albertson, and Andrew Riegel*
Temperature relationships in the megascolecid earthworm, *Pheretima hupeiensis* *William C. Grant, Jr.*
Natural revegetation of spoil banks in central Pennsylvania *William C. Bramble and Roger H. Ashley*
Population changes and roosting time of starlings *David E. Davis*
Seasonal development in sun and shade leaves *Yoko Anderson*
The seasonal life history of Daphnia in an arctic lake *W. T. Edmondson*
Xylem layers of trees as related to weather and altitude in the northern Rocky Mountains *R. Daubenmire*
The skin and respiratory water losses of *Peromyscus maniculatus sonoriensis* *Robert M. Chew*
Effect of hemlock and red pine on physical and chemical properties of two soil types *Francois Mergen and Robert M. Malcolm*
Studies from the autotrephon, III. A black mutation of *Tribolium confusum* compared with the normal reddish-brown strain *John Stanley and H. M. Slatis*
Testing the line-strip method against full tallies in diverse forest types *Alton A. Lindsey*
Nesting and production of the mourning dove in Texas *Wendell G. Swank*
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THE QUARTERLY REVIEW of BIOLOGY

BACKGROUND ADAPTATIONS

BY GEORGE HOWARD PARKER

Harvard University

The editors are pleased to publish this posthumous essay by G. H. Parker on that subject in which he had become the world's leading authority. Originally submitted for publication as one chapter in a book by various authors, this essay seemed more suitably published in *The Quarterly Review of Biology*, which he had served so long as a member of its Editorial Board.

INTRODUCTION

Living plants and animals are characterized far more than most natural objects by powers of adaptation. In fact, these powers are so commonly admitted to be of primal importance as to make them in the minds of many biologists the chief feature in the definition of living as contrasted with non-living bodies.

Adaptations enable one part of an organism to act on another in such a way as to advance the continued growth and life of the whole. The possession of powers of adaptation may thus be said to be the most characteristic feature in all organisms. So generally accepted is this idea that almost all recent definitions of life include this fact as an invariable part of such statements.

Nature, particularly on the organic side, abounds in adaptations. When food is given to a hungry animal the mastication of the nourishing materials not only induces reflexly the flow of the saliva and of other secretions of the mouth, but it starts up the activities of the next portion of the digestive tube, the stomach, in such a way that this organ is thus prepared to receive and help assimilate the food when it arrives. In this way the activity of one part of the tube excites in a preparatory way succeeding parts, so that a chain of reactions is initiated that helps in the nourishment of the individual as a whole.

All these steps are essentially adaptive in character and fitted to the kind of food taken. In this respect the body of any creature contains myriads of such sequences in which the activities of one region excite the next following, to the advantage of the creature as a whole. By this means organisms maintain the unusually high degree of adjustment seen in them. In all these operations the success of the process depends upon the nicety of adaptation that is called upon for the given state. When we realize that the bodies of all animals, including our own, are thus bound together by thousands of such adaptive chains for the well-being of the form concerned, we begin to get some conception of the enormous complexity that must rule in the life of even the simplest species of animal or plant.

ADAPTATIONS

Adaptations are as common on the exteriors of animals as they are in their interiors. They are well seen, for instance, in the coloration of the body coats of numerous creatures. That many animals

exhibit color adaptations between the tint of their outer coats and that of the general background on which they live has long been known to naturalists. Not only are the coat-colors of these animals related to that of their surroundings, but the color-cells that produce the tones often have the remarkable property of expanding or contracting quickly so as to fit with an astounding degree of accuracy a changing environment.

The essentials in such alterations were noticed and recorded by many early naturalists. Thus the Greek observer Aristotle as early as twenty-three centuries ago wrote accounts of these changes in his treatise on the *Natural History of Animals*. In the second book of that work he remarks that the chameleon can acquire either a black color like that of the crocodile or an ochreous like that of the lizard or a spotted with black like the panther, and that these changes take place over the whole body. In the ninth book of the same treatise Aristotle notes a similar trait among marine animals. The Polypus, a kind of devil fish, may pursue successfully other fishes that come near it by changing its color to imitate that of the neighboring rocks. It does much the same when alarmed. The Sepia, a relative of the Polypus, is also described by Aristotle as imitating the color of the place where it lives. In other words, these marine animals, like the chameleon, exhibit colors and color-changes which enable them in various ways to escape destruction by their enemies or to catch other animals which may serve them as food.

Although color changes in animals were known to classical antiquity, they did not claim the serious attention of naturalists till a little over a century ago. They were then taken up in such works as that of Cuvier (1817) on cephalopods and of Stark (1830) on fishes, but it was the monographic treatment of the color changes in the African chameleon by Brücke (1852) that put the subject on a thoroughgoing scientific basis. Brücke proposed and discussed some of the most important questions in the physiology of animal chromatic responses and laid the foundations for much of the work that has been carried out in this field during the last hundred years. This has been summarized in three extended reviews: one by the European physiologist, van Rhynberk (1906), another by the zoologist Fuchs (1914), and a third by the present writer (Parker, 1948). In these surveys, the contributions to this subject from ancient times to 1948 have been brought together and rather fully summarized. The bibliography of the subject has been fairly covered by these three publications, and for information of this kind the reader is referred to those sources.

CHROMATOPHORES

Color-cells, or chromatophores, are of several kinds and are usually classified in accordance with the kind of coloring matter within them. The most usual color-cells contain dark brown or black pigment and are called melanophores. They are assumed to contain melanin particles, but all melanophores do not always react in the same way to a given reagent. Thus to the extract from the eyestalks of a crustacean the melanophores in the shrimp *Crangon* concentrate their pigment while those in the crab *Uca* disperse it.

Chromatophores that contain red or yellow pigment soluble in alcohol or ether are designated collectively as lipophores; the reddish ones are known as erythrophores, the yellowish as xanthophores. Chromatophores that contain guanine or guanine-like materials reflect for the most part white light and are termed guanophores. If the guanine is in the form of granules and subject to change in position within the chromatophore, the color-cells are called leucophores; when the guanine is present as large, plate-like crystals and relatively fixed in position, the cells are called iridophores.

These chromatophores are single cells and contain in each instance a single kind of pigment. In addition to such simple color-cells there are also compound ones consisting of two or more kinds of color-cells distinguished by differently colored pigments, yet forming a single mass. Such compound groups may be designated as chromatosomes (Ballowitz, 1914), to distinguish them from the true unicellular chromatophores. Chromatosomes have already been identified in the crustaceans, the amphibians, and in some fishes.

ACTIVATION OF CHROMATOPHORES

Among the older workers in this subject it was customary to describe the stimulation of chromatophores as direct or indirect. By indirect stimulation was meant activation through nerves, and by direct stimulation that which resulted from any non-nervous means such as the application of chemicals or drugs in the blood to the chromatophores, or the impingement of light or heat from the external field on these cells. Of recent years direct stimulation has been limited to such obvious

external agents as heat and light which pass essentially unchanged through the immediate outer covering of the animal to the subjacent chromatophores. In this later usage indirect agents include not only nerves but any other means of chromatophoral stimulation that may arise within the body of the animal, such as internal secretions and the like. Indirect stimuli in this sense are often said to be either nervous or humoral; nervous when the response is due to a nerve terminal in immediate contact with the chromatophore, and humoral when it depends upon some substance carried by the blood or lymph to the color-cell. Nervous stimulation, which in the earlier days was the only form of activation suspected, has been shown in the last few decades to be really subordinate to humoral stimulation.

The movement in favor of humoral stimulation began some half a century ago in the discovery by Corona and Moroni (1898) that when adrenaline was injected into the body of a frog the animal blanched. Redfield in 1918 substantiated this discovery in his investigations of the color changes in the lizard *Phrynosoma*, and he was led to conclude still further that adrenaline was a normally produced activator in this lizard's own body. Through the researches of Adler (1914), Smith (1916), and Allen (1916), who developed the technique of hypophysectomy, it was shown that tadpoles without pituitary glands were always pale. Krogh (1922) also pointed out that the same was true of adult frogs. Hogben and Winton (1922), who had been actively engaged in experiments on frog nerves and pituitary secretions in regard to color changes, reached the important conclusion that in this animal nerves played a wholly insignificant part in the color changes, if in fact they played any part in it at all. These investigators showed that such changes were in truth dependent upon humoral substances in the blood of the frog. This view eventually gained general acceptance. Notwithstanding a rapid accumulation of evidence in favor of the humoral interpretation of chromatophoral activation, the nervous interpretation was still believed to hold for cephalopods, fishes, and lacertilians. The last two of these groups, however, were soon shown to involve with their nervous responses indubitable evidence of humoral effects. Thus a diversity of conditions seemed to prevail, in that in certain animals the color-cells were believed to be activated nervously, in others humorally, and in still others both nervously and humorally. In this way the distinction between nervous and humoral activation began to disappear. It became evident that the terminals of chromatic nerve-fibers excited their end-organs, the chromatophores, in the same way than many other effector nerve-fibers appear to excite their responding organs, namely, through minute amounts of substance which were passed from the nerve terminals to the effector color-cells. Hence, between the nerve terminal and the chromatophores there appeared to be the same relation as, for instance, between the adrenal gland and the chromatophore, in that a substance produced by one activated the other. Such a view is in strong contrast with the older conception of nerve stimulation. In this more recent interpretation of nerve activation, the distinction between it and humoral stimulation tends to disappear, for both types of activation rely for their effectiveness on certain liberated substances which, from a near or far source, reach and excite a given color-cell.

Substances that are produced in the nervous system or its appended glands and that serve as activating agents for other parts of the nervous system or its effectors have been variously called neurohumors (Fredericq, 1927), transmitters (Dale, 1935), neurohormones (Huxley, 1935), or chemical mediators (Cannon and Rosenblueth, 1937). Such substances are obviously hormones. In this discussion, however, they will be called neurohumors, as first proposed by Fredericq. A neurohumor may be defined as a hormone produced by any type of nerve-cell or by a gland controlled by such cells, and effective as an activator or inhibitor for other nerve-cells or for such effectors as color-cells. Such neurohumors are for the most part soluble in water and are consequently open to transportation by blood and lymph. In this way adrenaline, intermedine, and other like substances are conveyed from place to place. Still other neurohumors are soluble in fats and diffuse slowly through the oily constituents of the tissues. Acetylcholine appears to be a neurohumor of this kind, though it is also soluble in water. Water-soluble neurohumors have been called hydrohumors and oil-soluble ones lipohumors (Parker, 1934). Probably further study will bring to light still other types of exciting agents. From this standpoint, the nervous stimulation of chromatophores as a special type of activation seems to disappear, in that it proves to be a form of humoral stimulation in which the exciting substance comes from a nerve

terminal. Ordinarily this substance is produced in close proximity to the color-cell itself.

ANIMALS WITH BACKGROUND ADAPTATIONS

Almost all multicellular animals, including the sponges, coral animals, jelly-fishes, worms, crabs, and lobsters, as well as insects, the snails and clams, and the groups of back-boned animals such as the fishes, the frogs and toads, the reptiles, birds, and common beasts or mammals, possess pigment cells. The most usual type of pigment-cell present in these animals is the one with black pigment, the melanophore. Whether there are animals completely devoid of melanophores cannot at present be maintained. The oft-quoted instance of this kind is *Proteus anguinus*, a salamander from the subterranean waters of Carniola, Carinthia, and Dalmatia. The caves of Adelsberg, not far from Trieste, are celebrated for the occurrence of *Proteus*. Here deep below the surface in absolute darkness, and in water at an almost constant temperature of 50°F., is the habitat of *Proteus*. This animal is scarcely a foot long, and its whole body is of a slight rosy tint. It is easily kept in captivity, but if light is not absolutely excluded it becomes in time cloudy, and in strong light it may turn eventually jet black. Albinos, with absence of the dark pigment, have been recorded in young *Bombinator pachypus* by Fatio, in *Alytes obstetricans* by Latasti and Héron-Royer, in *Discoglossus pictus* by Boulenger, in *Rana esculenta* by Pavesi, in *Bufo viridis* by Born, Camerano and Boulenger, and in *Rana temporaria* by Lessona, Fischer-Sigwart, and Camerano (see Boulenger, 1897). These albinos are of a uniform yellowish flesh-color with silvery or golden iris and cherry-red pupils. The complete absence of melanophores from these forms is, however, nowhere affirmed.

Many lower animals change their tints with change of illumination. Thus in 1896 von Uexküll recorded that the Mediterranean sea urchins *Centrostephanus* and *Arbacia* darken in bright light and blanch in darkness. The leeches, most of which have brightly colored skin-patterns, have also been found by numerous workers to be darker in bright light than in darkness, where their skins tend to blanch (see Parker, 1948). These unusual conditions were studied sometime ago in the Mexican axolotl by Babák (1910). In young axolotls they made their appearance when the larvae of this salamander were about one and a half centimeters long. In complete darkness such small creatures were pale, but in bright light they became dark. When these larvae had attained a length of five centimeters they almost reversed this response, in that in complete darkness they were dark and in bright light they were pale on a white background or dark on a black one. Of these two general conditions, the early larval one was called the primary color phase and the succeeding one the secondary phase. It was Babák's belief that the primary phase was due to the direct stimulation of the dark color-cells, melanophores, by light and that the secondary one resulted from the indirect stimulation of these cells through the eyes and nervous connections. Although Babák's explanation of the primary phase has been in part rejected, his idea of the sequence of a primary by a secondary one has been shown to occur in many animals. Thus the primary phase appears to mark the early and permanent conditions in many invertebrates such as those mentioned in the beginning of this paper. This phase is at best temporary in the higher animals where, according to Babák, it is commonly replaced by the secondary one. Babák's conception, though an extremely ingenious one, is however open to further investigation. Its relation to the new view of neurohumoral activation is also of course not yet tested.

CONCEALING COLORATION

Examples of adaptive coloration are probably more abundant and remarkable in the group of arthropods than in any other large group of the animal kingdom. These examples have been very fully reported upon by Cott (1940), who has classified the examples of color adaptations in animals under three general heads: color schemes for concealment, for advertisement, and for disguise. This classification will be adopted in the following chapters.

Concealing coloration, to consider this class first, is well represented throughout the animal kingdom, but is especially often met with among insects. Although striking examples of this type of coloration are commonly assumed to be found only in distant and inaccessible parts of the globe, many of them occur near at hand, in fact at our very doorsteps. Of these the large noctuid moths of the genus *Catocala* are striking instances. The North American fauna is unusually rich in species of this genus, known to every collector of butterflies and moths. In some of these noctuids the spread of the wings may be three inches or more. In most species the fore or upper

wings are dappled light and dark gray, with some brown often interspersed, and would be described on the whole as inconspicuously tinted. The hind or under wings, on the other hand, have pronounced black markings on a mild background of red, pink, yellow, or white, according to the species. In consequence of the striking coloration of their lower wings, the members of this genus have been given the common name of underwing moths.

These moths can be found flying about in open woodlands even in the daytime, and when on the wing are reasonably conspicuous. On settling down after flight they almost invariably come to rest on tree trunks, and in so doing fold their colored underwings close to the body and cover themselves completely with the two approximated upper wings. The plan of coloration of the upper wings is so close to that of the trunks of the trees on which they rest that the closest scrutiny is often required to discover the moth as it clings to the bark. In fact, as this creature alights on a tree and covers itself with its upper wings it gives the impression of disappearing into the woody substance of its temporary resting place. Underwing moths when not in flight commonly rest on tree trunks in complete quiescence and are in consequence remarkably inconspicuous. It is well known to insect collectors that the darker species of *Catocala* frequent trees whose bark is dark, such as oaks and the like, and that the paler species are usually found on trees with paler bark, like the beeches. Taking all in all, it would be difficult to find a more perfect instance of concealing coloration than that shown by these moths, whose habits and color scheme aid so perfectly in their apparent obliteration.

A second example of concealing coloration is seen in the common crabspider, *Mitsumeria vatia*, of our countryside. This spider, the females of which may measure as much as half an inch in length, is found very generally in the yellow flower clusters of the goldenrod. The tint of the spider agrees so exactly with that of the flowers that it is with the greatest difficulty that it can be seen nestled in among the yellow blooms. It is most easily discovered by shaking vigorously the flower clusters of the goldenrod over a shallow box, whereupon the yellow crabspiders will be dislodged and easily caught. Under ordinary conditions these spiders rest hidden in the cluster of blooms, where they remain unnoticed by the numerous insect visitants of the flower. The spider is thus enabled under favorable conditions to pounce unexpectedly upon its prey, seize the insect, and suck its juices. Though *Mitsumena* is not a large spider, it is known to attack with success insects of the size of bumblebees. In this way the concealing coloration of the crabspider is an effective means in enabling this arachnid to obtain its supply of food. *Mitsumena* occurs not only on the yellow flower-clusters of the goldenrod but also on the white masses of bloom of the wild carrot or Queen Anne's lace. When the crabspider is associated with the wild carrot it is white instead of being yellow in color. These color differences are said to be determined by the spider's environment.

The two examples of concealing coloration described in the preceding paragraphs, that of the underwing moth and that of the crabspider, represent the two chief types of this kind of coloration. In the crabspider on the goldenrod the yellow color of the creature enables it to pounce successfully on its unsuspecting prey. This type of concealing coloration has therefore been called aggressive or offensive, and is shared by not a few other animals. The mottled changeable color of the octopus or devilfish, as originally pointed out by Aristotle, enables this creature in its rocky habitat to creep up upon fishes unperceived and seize them as prey. The white coat of the polar bear in its background of snow aids that beast in its approach to and capture of its chief source of food, the seal, as this animal rests by its fishing hole in the ice. Many other instances of aggressive concealing coloration are known. These are, however, far outnumbered by the examples of the type of coloration for concealment represented by the underwing moth. In this instance the insect when at rest is overlooked by such foes as predatory birds and the like because of its resemblance to the bark of the tree on which it may have settled. Such a type of coloration has been called protective, and in that sense is a defensive one. The group of insects abounds with innumerable examples of protective coloration, the green leaf-insects, the green and the brown walking-sticks, the multitude of green caterpillars with their rib-like stripes, and hosts of other cases. Under this type falls the brown, mottled coloration of partridges and pheasants and the truly remarkable change of color in the pelage of the varying hare, dun-colored in summer and white in winter. Here also belongs the intense and varied coloration of tropical birds, which though showy and brilliant beyond words in museum cases are lost to view in the tropical rain-forests where they flit about amid ever-changing intense shadows and

sunlight and are indistinguishable from their surroundings in consequence of the welter of color change about them. Thus a host of instances of protective coloration, along with those of the aggressive type, exemplify what has been designated as concealing coloration. These are nature's efforts at the camouflage so extensively practiced nowadays by man at war. We believe ourselves to be in this and other matters thoroughly up to date, but the paleontologist can point to fossil walkingstick insects as far back in the history of the globe as the Jurassic Period, thus showing that these insects practiced camouflage as long ago as 150 million years. Pride goeth before a fall.

MIXED CONCEALING AND ADVERTISING COLORATIONS

An instance of mixed coloration with concealing and advertising instincts is to be seen in the common mourning-cloak butterfly, *Vanessa antiopa*. This butterfly is common in the northern parts of Europe and North America. In New England it is the first butterfly to appear in the spring. It hibernates over the winter in the hollows in stone fences, in the cavities of old, partly decayed trees, and in old barns and other farm buildings. It may be seen flying about in the sunshine of an early spring day when in the sunny spots in the woods it is prepared to lay its spring eggs. The four wings of this butterfly are on the under side dark brown and mottled black. The upper sides of these wings are richly colored with beautiful blue spots on their marginal pale borders. The following description of this butterfly by Hawthorne, who must have been familiar with the originals in the New England woods, is given in the *Mosses from an Old Manse*, where he declares "rare butterflies come before the snow is off, flaunting in the chill breeze, and looking forlorn and allastray in spite of the magnificence of their dark velvet coats with golden borders."

These mourning-cloak butterflies come from their hiding places in the early spring to lay their eggs and then shortly afterwards die. During this brief spring life they sport about in the warm sunshine of the woods and respond to it in a remarkable way. Half-a-dozen of them can often be seen together where they will rest in the bright light, exhibiting to the fullest the striking colors of the upper surfaces of their wings. While this advertising is going on a pair may fly off, only to return shortly to the same sunny spot, where they again settle with their wings open and their colors in full display. This is evidently an advertising response for the pairing habit. If now the observer should temporarily disturb them by moving a little, they will at once fold their wings, thus covering their display of colors, and seem to disappear, for the exposed undersides of their wings now resemble the earth on which they rest. Thus the two sides of the wings of *Vanessa antiopa* serve in these two ways: the upper brightly colored faces as advertising agents and the under dun-colored ones as concealing agents.

ADVERTISING COLORATIONS

If the mourning-cloak butterfly possesses two color schemes, one for concealment and the other for advertising, there are other insects in which the color scheme illustrates in a simple way the purely advertising type. Such types of coloration are believed to be met with in insects like the bumblebee and other like forms whose possession of a sting is in this way advertised.

Bumblebees are as much a part of the summer flower-garden as the flowers themselves. In their busy, ostentatious way these insects are the gossips of their native haunts and carry their stores of pollen from flower to flower, receiving a drop of nectar in return for what they bring. Though cumbersome, noisy, and fretfully active, they are a part of their surroundings notwithstanding the conspicuousness of their color scheme. A garden without them would seem devoid of life, for they are fitted in size and color contrast with the world in which they live. Here they spend sunny days in full possession of what nature gives them freely and man cannot withhold. In general color they are dark, often really black, and yet marked with conspicuous transverse bands or spots of yellow or even orange and red. Kill me a red-hipped bumblebee on the top of a thistle, says Shakespeare. Bumblebees are so common that we fail to note how conspicuous they are even amid the flood of colors of the summer garden. If the crabspider is tinted for concealment, the bumblebee is colored for advertisement.

What the bumblebee advertises is its vicious sting. Sooner or later we learn to leave this insect to itself and more or less unconsciously set down its coloration as that of something to be avoided. The sting is an organ carried only by the queens and the workers, the two classes of females in the species. The males are without such organs, yet notwithstanding this we avoid them as we do all other bumblebees without inquiring into their sex. Thus we court security even at the expense of knowledge.

The principle of advertising coloration illustrated by the bumblebee is believed to hold for the great majority of conspicuously colored animals. Creatures that in their natural haunts stand out as strikingly visible may well be suspected of harboring disagreeable and often dangerous traits. To this category belong the other stinging insects, such as the common bees and wasps, and the brilliantly colored mutillas with their fiery needles. Among the higher animals the skunk is believed to notify the inquisitive of its offensive traits by its highly contrasted coat. Such colorations are often described as warning.

DISGUISE

The third and last general heading in animal coloration used by Cott is what he has designated disguising coloration. It includes among other instances those of mimicry. This phenomenon is again best seen in the insects. In such instances a given species whose family coloration is of a definite type abandons this coloration and assumes that of another group of quite different organization. As already stated, this change is believed to be to the advantage of the imitator. The animal imitated is commonly called the model and the imitator the mimic. An example of this kind is seen in two of our common butterflies, the monarch, *Danais plexippus*, and the viceroy, *Basilarchia archippus*. The monarch is our largest butterfly and may in exceptional cases measure fully four inches across the wings. The body color of its wings is brown with dark veining and a fairly broad dark, almost black marginal band which is particularly wide at the outer angles of the forewings where there are numerous light spots. The monarch frequents open fields and is especially associated with milkweed, on which it lays its eggs. Hence it is often called the milkweed butterfly. It is vigorous in flight and is noted for its extensive migrations. The viceroy butterfly is somewhat smaller than the monarch. Its wings spread at most three inches. The body color of the viceroy is brown, almost exactly that of the monarch. Its wings have a dark veining with marginal bands and pale spots, in striking agreement with the corresponding parts in the larger insect. In fact, the two butterflies, except for size, are almost identical. The viceroy is also a butterfly of the open fields. Notwithstanding these numerous points of similarity the monarch belongs to a different subfamily, the Danainae, from the viceroy, which is a member of the Nymphalinae. These two subfamilies differ structurally. Thus in the danaids the antennae are naked; in the nymphalids they carry scales.

When the other members of the two genera to which the monarch and the viceroy belong are compared, a striking contrast is to be observed. The coloration of other danaids is brown and in very close agreement with that of the monarch. The near relatives of the viceroy on the other hand are dark in color and often of a purplish tone. Thus in the nymphalid known as the banded purple, *Basilarchia arthemis*, the wings have a very dark ground tint with a concentric system of broad white bands and with rows of marginal dots and lunules, some reddish and others blue, thus giving it a purplish tone. Other members of the genus *Basilarchia* are in color much like the banded purple. None of them resemble the viceroy.

From these facts it is to be assumed that the monarch has remained true to its family coloration, but that the viceroy has departed from its traditional color scheme. In the combination of the monarch and the viceroy, then, the former must be the model and the latter the mimic.

In what respect does the viceroy profit by its change of coloration? The group of butterflies to which the monarch belongs is noted for their rank and disagreeable odor. Collectors of insects are familiar with this trait in all danaids. This feature may well be repellent to birds and other predacious animals. No such odor is associated with the viceroy, which may, however, profit by its color resemblance to the monarch and be left untouched by the common foes of butterflies. Thus the viceroy is believed often to escape destruction which it might well otherwise meet. If monarch and viceroy are related as here outlined, the geographical distribution of the two species ought to be such that the area occupied by the mimicking viceroy should be within that of the model monarch. If this were not so, the mimic would be unprotected in its extraterritorial area. As a matter of fact, in these two butterflies this condition is fully met. The monarch is found over the whole of temperate North America from the Atlantic seaboard to the Pacific coast and southward to the Gulf of Mexico. The viceroy, on the other hand, is limited to the eastern portion of this range and nowhere extends beyond it. Thus these two butterflies afford a good example of mimicry in their coloration and show in their areas of distribution a conformity to the theoretic requirements.

The three main classes of animal coloration, as outlined by Cott, have now been illustrated by one

or two examples each and have received what may be described as a sympathetic presentation. What can be said by way of criticism of this whole treatment of animal coloration? The chief weakness of this view, inviting as it is in some respects, lies in the fact that it is almost purely hypothetical and lacks that kind of evidence which is ordinarily looked upon as conclusive. Such evidence must come from experimental tests. Are underwing moths really protected by resembling the bark of the trees on which they alight? Could not the crab-spider, if of another color than that of the flower head in which it lurks, catch its prey with equal success? Such questions as these must be answered first before an unqualified assent can be given to the adaptive interpretation of animal coloration. Some experimental evidence on this general problem has as a matter of fact already been acquired, but it is scarcely more than a beginning. Sumner subjected numbers of pale and of dark mosquito fishes, *Gambusia*, to attacks from several predators, the Galapagos penguin, the night heron, and the blue-green sunfish. In each trial equal numbers of dark and of pale mosquito fishes were liberated in one test over a black background and in another over a pale gray one. A predatory bird or fish was then allowed to feed upon them. As a result of these tests it was found that the mosquito fishes which fitted the backgrounds were less numerously seized and eaten than those that were of contrasted tint. In a general summary of the whole set of experiments made by Cott it was shown that of 2,672 fishes offered as prey, 1,150 were reckoned as casualties, of which 395 (34 per cent) were of the less conspicuous individuals and 755 (66 per cent) of the more conspicuous ones. Plainly there was shown in these tests a real advantage to the possessor of the so-called protective coloration. It is experimental evidence of this kind, obtained either from the laboratory or from the field, that will settle many current problems of animal coloration; and such settlement will be more conclusive than that based on wordy discussion.

ANIMALS WITH RAPID COLOR CHANGES

Animals with the remarkable capacity of rapid color change have long been known, and their significance for the general theory of adaptive coloration has been fully recognized. Besides a few sporadic instances of this kind of change among such creatures as the sea-urchins, the leeches, and the insects, the animals that show this remarkable capacity are found in three independent groups: the cephalopods, such as the devilfishes and squids; the crustaceans, including the shrimps, prawns, crabs and the like; and the cold-blooded vertebrates, the fishes, frogs, salamanders, and many of the reptiles, especially the lizards. Among the vertebrates the fishes have received perhaps the most attention, and these animals will serve as a basis for the following account.

The majority of fishes can be shown to exhibit more or less change of color. In tests of this kind some fishes, like the squirrel fish of Bermuda, will change from pale to dark or the reverse in a few seconds, while others, such as the common New England catfish, will require from one to several days to make these alterations. Color changes are brought about by readjustments in the pigment content of the color-cells, or chromatophores, in the skins of these animals. The most usual kind of vertebrate chromatophore is the melanophore. In the pale condition of such a fish as the catfish the pigment is collected about the centers of the color-cells; in the dark condition it is scattered throughout the bodies of the cells and their processes. The shifting of the pigment back and forth within the color-cell is what changes the tint of the fish.

In addition to the melanophores many fishes possess true color-cells with characteristic pigments: xanthophores with yellow, erythrophores with red, and leucophores with white. In many fishes there are groups of crystalline plates which vary greatly in color and which are covered or exposed by the migration of the pigment in the surrounding melanophores.

Depending upon their chromatophores, different fishes exhibit different degrees of color activity. The common catfish, possessing only melanophores, has a limited color range from a pale greenish yellow to a coal-black. In the killifish in addition to melanophores there are xanthophores, leucophores, and green-blue chromatosomes. These fishes change not only from dark to pale, but they may assume yellow, green, blue, or even red tints. The red coloration is due to an enlargement of the integumentary blood vessels, a true blush. The color changes in tropical fishes are like those in the killifish except that they are much more exaggerated. In some of these fishes even the general pattern seems open to change, almost to obliteration, as in the Nassau grouper. The southern flatfish, *Paralichthys*, will respond roughly to different checkerboard patterns by becoming more finely or coarsely spotted in accordance with its back-

ground. Such pattern changes, mostly due to melanophores, when coupled with true color changes give tropical fishes an almost limitless range of tints.

How these color changes in fishes are controlled has been a problem for a century past. In 1852, Brücke pointed out that when cutaneous nerves in the chameleon were cut, the areas of skin thus denervated darkened by the dispersion of their melanophore pigment. In 1858 Lister, then a young student of medicine, discovered that in the common frog the eyes were essential to color changes, and he declared in favor of a nervous interpretation of vertebrate chromatism. Pouchet, whose work on fishes confirmed that of Brücke on the chameleon and of Lister on the frog, showed that the part of the nervous organization concerned with color changes was the sympathetic or autonomic system, a view subsequently supported by von Frisch and many other workers. Thus the nervous interpretation of the phenomena of color change in vertebrates became paramount.

Meanwhile Hogben and Winton, who had been actively engaged in the study of the chromatism of the frog, were led to conclude from their experimental tests that in this animal nerves played a wholly insignificant part in color change, if in fact they played any part at all. Evidence obtained from experiments on the frog's pituitary gland, which is situated in the base of its brain, led these investigators to declare that the dark color of this amphibian was due to a substance, a hormone, produced in the pituitary gland, whence it was carried by the blood to the melanophores throughout the body. The pale color of this animal they believed to be due to the absence of this substance. Thus the occasion of the color changes in this amphibian was shifted from nerves to a blood-borne hormone. This substance, later called intermedine, thus became the all-important factor in the chromatism of the frog. From this and other work it was concluded that though the color changes in fishes and reptiles were dominated by nerves those in amphibians were essentially hormonal.

This novel and somewhat anomalous situation stimulated further work on the color changes in the lower vertebrates, particularly in the fishes. Much of what is new in this field can be illustrated by the color responses of the common New England catfish *Ameiurus*. As already stated, this fish ranges in tint from a pale greenish yellow to a coal-black. It possesses only melanophores. These are of two kinds, large in the derma and small in the epidermis. In the pale phase the pigment in each color-cell is reduced to a dot, large or small; in the dark phase it is spread throughout the color-cells and their branches.

To what extent are the color-changes in fishes like the catfish under the control of nerves, and is there any evidence of hormone action in such creatures? In the catfish, as in many other common fishes, there is good evidence that the color changes are at least partly under nervous control. If, following the procedure originated by von Frisch, a particular spot in the medulla oblongata of the catfish is stimulated electrically, the whole fish will quickly blanch (Abramowitz, 1936). This response, however, does not include denervated areas. Hence it must be nerve activity that induces it, for where nerves are absent it fails to appear. Thus the concentration of melanophore pigment in the catfish must be occasioned by nerves. Responses of this kind have been observed many times in numerous fishes and have long been accepted as conclusive evidence for the presence of concentrating nerve-fibers in these animals. The opinion that this type of nerve-fiber is present in fishes and as a matter of fact also in certain lizards seems established beyond all doubt.

Whether there is an opposing type of nerve control for melanophores is not so easily demonstrated. From the time of Brücke it has been believed that the dark areas of skin due to the cutting of cutaneous nerves are the result of the paralysis of the concentrating fibers and their color mechanism. It is possible, however, to show the incorrectness of this view even on catfish. If a bundle of nerves in the tail of a pale catfish is cut, a dark denervated caudal band will quickly appear. This band represents what the older workers regarded as the paralyzed region of the color system. After a day or two, however, such a band will blanch considerably, and if now it is recut in a region slightly distal to the initiating cut, the band will again darken. Such a redarkening could not occur if the band was actually paralyzed, for the band should then be inactive. This second darkening makes it clear that the color mechanism of the band is still functional and far from paralyzed. Hence the view that the caudal and other like bands are paralyzed must be incorrect. The most probable explanation of this phenomenon is that the cut chromatic nerve contains at least two sets of fibers, one of which, the concentrating set, is open most easily to electric stimulation, and the other, the dispersing set, is

stimulated most easily by cutting. Such a view implies double innervation for catfish melanophores and puts them in the same category as the heart-muscle of the higher vertebrates, where one set of nerve-fibers accelerates and the other retards this organ. It is interesting to observe in this connection that in the innervation of the melanophores of the perch and other fishes, as worked out histologically by Ballowitz in 1893, not one but several nerve-fibers as a rule are distributed by numerous terminals to each color cell. Of course, one fiber might well be a concentrating element and another a dispersing one. Thus even the histological findings in this field are favorable to the idea of a double innervation. As a matter of fact, double innervation of chromatophores was long ago suggested by Bert (1875) for these cells in the chameleon, but without supporting experimental evidence. This view of chromatophoral innervation, at least in the common fishes, seems now to be gaining more general credence (Waring, 1942) than when it was reaffirmed a decade or so ago (Parker, 1932).

From the evidence thus far presented it is clear that the catfish, like other members of its group, has a very complete nervous mechanism for the control of its melanophores. Nor is there any reason to believe that it needs more. It is, however, not without importance to raise the question whether this fish may not possess other means of controlling its melanophores than the two sets of nerve-fibers already described. If such another activator were present it might well be the secretion from the pituitary gland, intermedine. After the removal of this gland from a catfish the creature presents a remarkable limitation in its capacity for color change (Abramowitz, 1936). Although such a fish can become fully pale, it is unable to darken in normal dark surroundings to more than what would be called an intermediate stage. Apparently this is the limit of efficiency for the dispersing nerve fibers, the one obvious darkening agent left. If into such a partly dark fish a quantity of intermedine is injected, the fish will darken fully. This test indicates that the complete darkening of a catfish is dependent upon intermedine, which can also be shown to be capable in itself of carrying catfish to a completely dark state. Hence catfishes appear to have another darkening agent in addition to the dispersing nerve-fibers. They thus may be said to possess, in all, three well-established melanophore activators: for darkening, pituitary intermedine and dispersing nerve-fibers; and for blanching, concentrating nerve-fibers.

The catfish, from the standpoint of its kinds of melanophore control, thus presents an extremely interesting condition, for it possesses not only a nervous mechanism in its color system but also a hormonal one. This combination, which is found in a number of other common fishes, indicates a much closer relation between these two means of color control than that implied in the general statement that fishes and reptiles activate their color-cells by nerves and amphibians by hormones. How in fact are these two systems related?

The hormone intermedine is produced in the pituitary gland of the brain, whence it is carried in the blood and lymph of the fish to the melanophores in the skin, the pigments of which are thus stimulated to disperse. This is a very simple and direct way of applying an activating agent to its responding part. How do the two sets of chromatic nerve-fibers stimulate color-cells? These two sets of fibers belong to the autonomic nervous system and might well be supposed to act on the color-cells through the two activators so common in this system, adrenaline and acetylcholine. Is there any evidence that these substances are associated with the catfish color system?

Appropriately made extracts of catfish skin can be examined for adrenaline by a biochemical test as shown in the responses of a Straub frog-heart preparation. Adrenaline is destroyed by heat. When unboiled and boiled extracts of catfish skin are applied separately to Straub frog-heart preparations, a vigorous response is elicited by the unboiled extract and a very faint reaction by the boiled one. As these tests are specific for adrenaline, the excess of response to the unboiled over the boiled extract must be due to this agent. It is therefore clear that the unboiled skin extract must contain some adrenaline. Bray showed as early as 1918 that 0.2 cc. of adrenaline one part in a million of Ringer's solution would on injection blanch a whole catfish, an observation substantiated by many subsequent workers. Taking these several observations together it is beyond doubt that adrenaline is a constituent of the catfish skin, and very probable that it is the agent which in conjunction with the concentration fibers induces the melanophores of this fish to concentrate their pigment.

In a similar way a biological test for acetylcholine can be made use of in the responses of

strips of leech-muscles to appropriate fish-skin extracts. This method, moreover, allows of quantitative results. By its use the amount of acetylcholine per gram of wet fish skin has been found to be 0.078 μg., or about one part of acetylcholine to 13 million parts of skin. It is not easy to appreciate the smallness of this quantity of acetylcholine. If we assume the distance from Boston to New York, some 230 miles, to represent a gram of skin, the weight of acetylcholine, 0.078 μg., would be equal in such a distance to about an inch. This comparison may give us some conception of how small the effective amount of this agent is in a catfish's dark skin. While this determination was being worked out in the Harvard Laboratories, another made by the same method was published by Chang, Hsieh, and Lu of the Pekin Union Medical College on the skin of the Chinese snakefish. The determination by these investigators was 0.077 μg. of acetylcholine per gram of skin. The closeness of these two determinations must be regarded as in a measure accidental, for it is unlikely that such uniformity exists. The two numbers, however, show in their approximation the order of magnitude of the amounts of acetylcholine involved and make it fairly certain that these amounts are prodigiously small. Acetylcholine when injected into catfishes with proper precautions will darken them. Hence this substance may well be the agent associated with the dispersing nerve-fibers in their darkening effect on the catfish skin.

If, as is suggested by the preceding consideration, concentrating nerve-fibers act on melanophores through adrenaline, and dispersing fibers through acetylcholine, the melanophores must be subject to much the same type of stimulation by nerve-fibers as by intermedine, in that in both instances there is a direct application of a dissolved activator to the outer surface of the color-cell. This tentative view leads to two important conclusions. The first is that the frequently made distinction between stimulation of color-cells by hormones and by nerves is of very little significance, for both methods are in reality the same and depend upon dissolved materials applied to the color-cells. And the second conclusion is that the type of stimulation in the chromatic system falls exactly in line with what is being developed at present for the nervous system in general, namely, that one nervous unit, be it sense cell, nerve cell, or appended cell, is stimulated by another not through purely electric disturbances that pass from one unit to the next, but by substances such as the three herein named. These substances are generated by the discharging unit and activate the receiving one. According to this view, such substances are the universal means of passing impulses from one element in the nervous system to the next, and are thus of first importance in the physiological integration of nervous activity. They have been variously called chemical activators, neurohormones, transmitters, neurohumors, and the like, but the substances thus designated all act to the same end, the transmission of nerve impulses from one nervous unit to its neighbor. It is gratifying to observe that the study of the color changes of animals supports this general conception of nerve activity, perhaps one of the most important steps in the modern study of the nervous system, that system of organs which has more to do with making us what we really are than any other system in our whole physical organization.

LIST OF LITERATURE

The references in this paper to older publications will be found in full in the lists contained in the bibliographies already printed in the following three communications.

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THE COMPARATIVE PHARMACOLOGY OF THE SUPRARENAL MEDULLA

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HISTORICAL INTRODUCTION

TO trace animal tissues which produce adrenaline or its related compounds, biologists have used extensively the chromaffin reaction, first described by Henle in 1865. He showed that chrome salts give a characteristic color to cells of the suprarenal medulla. The brownish-yellow color was thought to be due to combination of the chrome salts with oxidation products in the medullary cells, but recently, it has been shown that the reaction occurs independently of chrome materials, and is due to the oxidation of adrenaline-like compounds producing brown melanin-like derivatives (Bennett, 1941). The pressor amines, adrenaline and noradrenaline, give this reaction, but so do other substances which are considerably less active physiologically and pharmacologically (West, Shepherd, Hunter, and Macgregor, 1953). When these other substances that react similarly are absent, the chromaffin reaction depends on the presence of adrenaline and noradrenaline in the cells. There is then correlation between the intensity of the reaction and the content of pressor amines, so that the original color reaction still remains of great value to all persons investigating these types of cells.

Oliver and Schäfer in 1895 were probably the first to report that the intravenous administration of extracts of suprarenal glands produces hypertension and marked tachycardia. This observation was verified shortly afterwards by a number of investigators and led to the purification and isolation by Abel and Crawford in 1897 of one of the active principles of the suprarenal medulla. Takamine chemically identified this material in 1901 and named it adrenaline, which therefore became the first hormone to be isolated. Not long after, it was synthesized by Stolz (1904), and the identity of the naturally occurring product was proved beyond doubt.

Since small intravenous doses of adrenaline are generally lethal to animals, it is interesting to find that the amine exists in the poison glands of certain species. Its presence not only enables the animal to prey on "lower forms" of life but also serves as a protective mechanism when the possessor is preyed on by other animals. For example, Abel and Macht (1912) showed it to be a constituent of the secretion of the two large oval parotid glands and of certain of the cutaneous glands of the tropical toad, *Bufo agua*, though true chromaffin tissue is absent in these organs. This means that chromaffin tissue is not always necessary for the production of adrenaline and its related compounds, and indicates one of the limitations of histological studies. Presumably an unreacting precursor exists inside the cell. This could be the allied compound, octopamine or *para*-norsynephrine, which according to Erspamer and Boretti (1951) exists in the salivary secretion of many cephalopods (such as *Eledone*, *Sepia*, and *Loligo*) and enables these creatures to paralyze their crustacean prey.

In the early studies of Lewandowsky (1899) and Langley (1901), attention was drawn to the striking similarity between the effects observed when sympathetic nerves to an organ were stimulated and the reaction in the corresponding organ following injection of extracts of the suprarenal glands. The brilliant suggestion that the transmitter substance at sympathetic nerve endings may be adrenaline was made by Elliott in 1905. However, as early as 1910, Barger and Dale cast doubt upon this theory, and Cannon and his coworkers in Boston (1921, 1933, 1937) later obtained results which were incompatible with the view that adrenaline is the only substance liberated at these nerve endings. Our present-day knowledge of sympathin is also founded on the pioneer research work of Loewi (1921, 1936), although he mostly used the frog heart, where it is now agreed that adrenaline is the chief sympathetic mediator. The theory that

the substance liberated on stimulation of the hepatic nerve in the cat is noradrenaline or some similar substance was first postulated by Bacq in 1934, but it was not until the studies of Euler in 1946 that direct evidence was obtained for the physiological importance of noradrenaline. Euler, working in Sweden, showed by biological methods that a substance closely resembling noradrenaline was present in extracts of fresh ox and cow spleen, the heart of the ox, horse, and cat, and also in nerves of the sympathetic chain. This seems to be one of the turning points in the story of the naturally occurring catechol amines, and with the aid of better techniques the significance of the observations of Barger and Dale has been fully appreciated in the past few years.

Noradrenaline is a primary amine, differing from adrenaline only by the absence of an N-methyl group (see Fig. 1). Both amines were synthesized

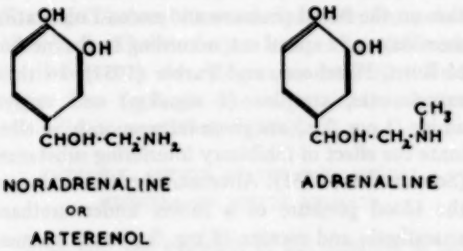

FIG. 1. THE RELATIONSHIP OF THE TWO AMINES

by Stolz in 1904. Like all dihydroxyphenyl derivatives, both are rapidly oxidized in the presence of oxygen, especially in an alkaline solution, or if heavy metal ions are present. They are, however, more stable in weakly acid solutions. In 1947, Holtz, Credner, and Kroneberg, working in Austria, established (a) that endogenous catechol amines are normally excreted in the urine of man, and (b) that noradrenaline is present with adrenaline in extracts of the suprarenal glands. In the same year, West made a comparison of the chemical and biological properties of the two amines, so that tests could be devised to decide whether the activity of an extract or perfusate is due to noradrenaline or adrenaline. Later workers such as Holtz and Schümann (1949), Bülbring and Burn (1949a), and Euler and Hamberg (1949b) also showed that noradrenaline as well as adrenaline occurs in the suprarenal glands, although the relative amounts of each vary greatly in different species. Any doubt as to the identity of this material was removed by biological and colorimetric comparison with the *laevo* form of noradrenaline which was prepared by Tullar in 1948. Further indications and proof that the two amines occur together in the suprarenal glands have been given by Goldenberg and his coworkers (1949), Tullar (1949), and Bergstrom, Euler, and Hamberg (1950). Extracts of the suprarenal medulla of cattle (e.g. epinephrine, U.S.P.) were shown by chromatographic and biological analyses to contain up to 36 per cent noradrenaline in the catechol amine fraction.

The early synthesis of adrenaline in 1904 led to a great reduction of interest in the biochemistry of the suprarenal medulla, and as mentioned above it is only during the last ten years that a reinvestigation of the chemical nature of the medullary secretions has been carried out in different countries. This review contains among other reports the results of further studies designed to investigate the function, and to evaluate the physiological importance, of noradrenaline in the suprarenal gland. It was considered that a study of the phyletic distribution of the suprarenal catechol amines might assist in this investigation, and specimens of elasmobranchs, Amphibia, Reptilia, Aves, and Mammalia were chosen for the following reasons: (1) the chromaffin tissue in elasmobranchs consists of paired, segmentally arranged bodies lying along the medial borders of the kidneys and Wolffian bodies and is completely independent of the interrenal body or rudimentary suprarenal cortex; (2) the chromaffin cells in Amphibia exist in islets scattered over the surface of the kidney and are not usually in direct connection with cortical islets; (3) the suprarenal glands in Reptilia and Aves are composed of interlaced medullary and cortical cells without any clear regional demarcation and hence represent the next step towards the arrangement of the two types of cells of the gland as seen in mammals; and (4) the suprarenal glands in all Mammalia consist of a separate medulla enclosed by a cortex, although their sizes and shapes exhibit enormous variations (Fig. 2). It was also considered important to investigate the glands at various stages of development in these species to determine (if possible) what influence the pituitary or suprarenal cortical secretions may have on the methylation of noradrenaline.

METHODS OF ANALYSIS

In order to study the occurrence and liberation of adrenaline and noradrenaline, quantitative

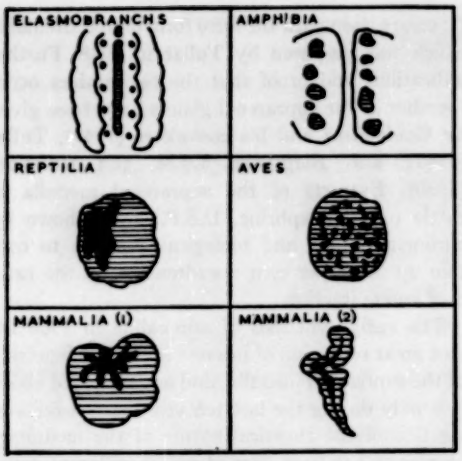

FIG. 2. THE RELATIVE POSITIONS OF THE SUPRARENAL CORTEX (horizontal lines) AND MEDULLA (shaded black) IN VARIOUS ANIMALS

methods are essential which make it possible to distinguish between the two compounds. Several extraction processes are available for the suprarenal glands, but all involve the use of acid to stabilize the pressor amines. The following account represents one of the procedures adopted in work of this nature when the assay methods are not only biological but also chromatographic and fluorimetric.

Preparation of the extracts

Human suprarenal glands are secured as soon as possible after death. A delay of 10 to 12 hours does not necessarily mean loss of pressor amines. After removal of the capsule and the fatty tissue adhering to it, the glands are weighed and ground in a mortar with sand and 0.01 *N* HCl (0.01–1.0 ml. per g. fresh tissue). The contents of the mortar are then transferred to a centrifuge tube and centrifuged. The supernatant fluid is pipetted off and clarified by the addition of 4 volumes of ethanol, followed by centrifugation and evaporation of the fluid to a small bulk (generally to one-fifth of the original volume). This concentrated fluid is then used for the estimation of the noradrenaline content by paper chromatography (as described below). For the estimation of the adrenaline content by paper chromatography and for the biological assays of both amines, this fluid is diluted with water to produce the original strength of extract.

The suprarenal glands of most other species are secured after killing the animals by a blow on the head or by an overdose of urethane. The glands of sheep, pig, ox, cow, and horse are taken from the slaughterhouse as soon as possible after death. The glands of the hare are removed after the animals have been shot in the fields. In all cases, the capsules are first removed, and the glands are weighed and ground in a mortar with sand and 1–5 ml. of 0.01 *N* HCl per g. fresh tissue. After centrifuging, the extracts are clarified and concentrated as described for the human specimens. It is impossible in certain cases (e.g. frog and toad) to weigh the glands accurately. In certain specimens from adult mammals, the cortices may be separated from the medullae; each part is then weighed, extracted and assayed separately.

Assay methods

Extracts may be biologically assayed for their adrenaline and noradrenaline contents by the action on the blood pressure and normal nictitating membrane of a spinal cat, according to the method of Burn, Hutcheon, and Parker (1951). In these experiments, atropine (1 mg./kg.) and mepyramine (1 mg./kg.) are given intravenously to eliminate the effect of inhibitory interfering substances (Schmiterlöw, 1951). Alternatively, the action on the blood pressure of a rabbit under urethane anaesthesia and cocaine (5 mg./kg.) may be measured (West, 1950b). In addition, assays may be carried out on the isolated rabbit ileum, both in the fresh and in the stored state (West, 1950b), on the isolated uterus of a non-pregnant rat (West, 1947), or on the isolated rectum of the day-old chick (Mann and West, 1950). Calculations for the estimates of adrenaline and noradrenaline in each extract are then made using the formula developed by Bülbring (1949). It is preferable to use one preparation where noradrenaline is at least twice as active as adrenaline (e.g. the blood pressure of the cat), and one where adrenaline is by far the more effective compound (e.g. rat uterus or chick rectum).

Separate estimation is also possible by paper chromatography. Chromatograms may be run in solvents of butanol - acetic acid - water, phenol - water, phenol - hydrochloric acid, or butanol - hydrochloric acid. The adrenaline concentration is estimated by comparison with standard amounts of pure base after development with aqueous potassium iodate (Shepherd and West, 1951), potassium ferricyanide (James, 1948), ethylene diamine

(Weil-Malherbe and Bone, 1952), or ninhydrin. For noradrenaline, the developing agent is a mixture of formaldehyde and potassium ferricyanide, as suggested by Shepherd and West (1953b). This combination of paper chromatography and fluorimetry enables the catechol amines to be estimated in the difficult problem in which one is present in concentrations far in excess of the other, since the two amines differ in sensitivity to spray reagents and in the shade of fluorescence seen in ultraviolet light. Other workers have used chemical methods of assay, such as the iodine oxidation method of Euler and Hamberg (1949a). Generally the biological and chromatographic results agree well, and in the following tables the mean values of the two assays are recorded where possible.

Standard solutions of L-adrenaline and L-noradrenaline bitartrate (1 in 1000 of base) were prepared in 0.01 *N* HCl from the pure substances, which were kindly supplied by Dr. M. L. Tainter, Sterling-Winthrop Research Institute, Rensselaer, New York. These solutions retain their full activity if stored in the refrigerator, and dilutions in water may be made from these stock solutions just prior to use (West, 1952b).

CATECHOL AMINES IN THE SUPRARENAL MEDULLA OF ADULT ANIMALS

Since the first evidence of the presence of noradrenaline (as well as adrenaline) in the suprarenal glands was presented in 1947 by Holtz and his coworkers, it has been found in the suprarenal medulla of most vertebrates. The early investigators (Schümann, 1949; Holtz and Schümann, 1949; and Bülbring and Burn, 1949a) indicated that there was considerable variation in the relative amounts of the two amines in the glands of different mammals, and so a systematic comparative study was initiated in Dundee to determine their normal resting amounts in a large series of animals. In this way, we might understand why the amounts vary so much from species to species. The early work was reported by Shepherd and West in 1951 and since then has been extended to many more species. Table 1 gives the results of the total pressor amine activities and the relative amounts of noradrenaline found in these totals. In the cases of the sheep, cow, and ox (Goodall, 1951; Shepherd and West, 1953c), small amounts of the amine, hydroxytyramine, are also found (see later under biosynthesis). Table 2 gives the results found in other species by other workers.

TABLE 1

Catechol Amines in Suprarenal Glands of Adult Animals
(Assays completed in Dundee)

Animal	Total Activity (mg./g.)	% Noradrenaline in the Total
Fowl	10.10	80
Dogfish	3.30	73
Torpedo	0.95	73
Turtle	2.50	60
Pigeon	3.00	55
Frog	3.10	55
Toad	3.60	55
Pig	2.15	49
Cat	0.97	41
Sheep	0.75	33
Cow	1.75	29
Dog	1.50	27
Ox	1.62	26
Mouse	1.00	25
Horse	0.84	20
Man	0.60	17
Hare	0.35	12
Rat	1.23	9
Hamster	0.40	8
Rabbit	0.48	2
Guinea-pig	0.15	2

TABLE 2

Catechol Amines in Suprarenal Glands of Other Adult Animals

(After Burn, Langemann, and Parker, 1951; and Goodall, 1951)

Animal	Total Activity (mg./g.)	% Noradrenaline in the Total
Insects	—	94
Whale	2.07	83
Lion	0.53	55
Squirrel	0.20	50
Wildebeest	1.43	42
Gazelle	0.92	39
Goat	2.23	37
Dik-Dik	0.12	36
Macacus	0.33	19
Zebra	1.93	17
Baboon	0.83	0

Generally speaking, there is a correlation between the total activity values and the percentage noradrenaline figures (Fig. 3). It is obvious that a gland composed of a small cortex and a large medulla will contain more pressor amine per unit

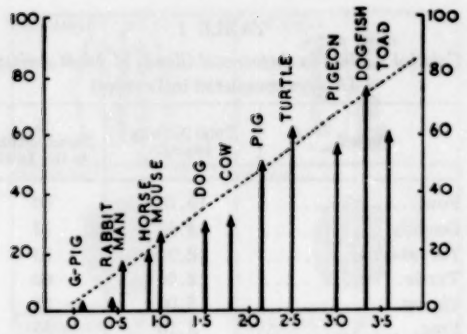

FIG. 3. THE RELATIONSHIP BETWEEN THE RELATIVE AMOUNT OF NORADRENALINE (ordinates, per cent of total) AND THE TOTAL PRESSOR AMINE ACTIVITY (abscissae, mg./g.) IN THE SUPRARENAL GLANDS OF VARIOUS ANIMALS

of tissue than a gland with a relatively large cortex. Thus, total activity values are high in extracts of glands of the fowl, pigeon, turtle or dogfish and noradrenaline predominates, so that the degree of methylation of noradrenaline may be related to the relative size of the cortical tissue. This is so for many of the species studied, and can be seen when the relative noradrenaline content is plotted against the ratio of the size of the cortex to that of the medulla (Fig. 4). In the fowl, for example, the cortical and medullary areas are nearly the same (ratio = 1) and the relative noradrenaline content is over 80 per cent, yet in the rabbit the cortical component occupies about 60 times that containing the medulla (ratio = 60) and the relative noradrenaline content is under 3 per cent. The results in the cat do not fit well into this scheme, but this may be due to the fact that the relative

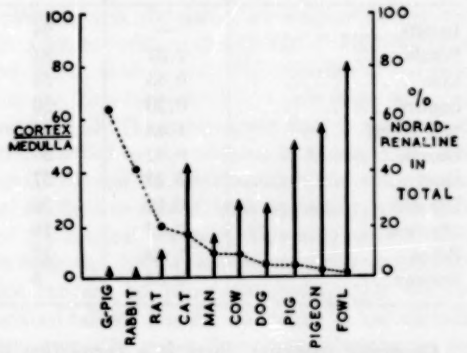

FIG. 4. THE INVERSE RELATIONSHIP BETWEEN THE RATIO OF CORTICAL SIZE TO MEDULLARY SIZE (●----●) AND THE PERCENTAGE OF NORADRENALINE IN THE TOTAL PRESSOR AMINE ACTIVITY (vertical lines)

TABLE 3

Catechol Amines in Chromaffin Bodies of Dogfish Species
(After Shepherd, West, and Erspamer, 1953)

Species	Total Activity (mg./g.)	% Noradrenaline in the Total
Squalus acanthias	3.30	73
Mustelis canis	3.20	69
Scylliorhinus canicula	3.35	66
Scylliorhinus stellaris	2.75	67
Torpedo marmorata	0.75	73

noradrenaline content of its glands varies widely from animal to animal (between 30 and 60 per cent of the total).

Although the relative size of the cortex may be a clue as to the relative amount of noradrenaline found in extracts of suprarenal glands of animals, it does not explain why adrenaline as well as noradrenaline may be present in tissue where the cortical component does not exist or is not in immediate contact with it. For example, in lower vertebrates where structures homologous to the suprarenal gland of higher vertebrates remain separated throughout life (as in the dogfish), extracts of each component can be made and tested without contamination from the other part. For example, five species of dogfish were used in the experiments of Shepherd, West, and Erspamer (1953) and both amines were found (Table 3). Hence it may be concluded that methylation of noradrenaline does not require the immediate presence of cortical tissue, although a hormonal factor (possibly of cortical or pituitary origin) might be necessary (West, 1951a; Coupland, 1953). In a further series of experiments using dogfish, Shepherd and West (1953a) divided the chromaffin bodies into three parts, two of which were well away from the interrenal body or rudimentary cortex (see Fig. 5). Extracts of all three areas, however, contained both adrenaline and noradrenaline in about the same proportions. This result is of interest since several workers have suggested that there may be a dependent relationship of the cortex to the differentiation of chromaffin cells. Willier, for example, pointed out in 1955 that during formation of the suprarenal gland groups of cells destined to become medullary tissue migrate through the cortex taking with them some cortical vascular connections. These groups of cells do not exhibit the chromaffin reaction until they have come into

contact with cortical cells. It may be that the cortex is directly concerned in the methylating process, though the limitations of the chromaffin reaction must again be stressed. In a later section, it will be seen that the Organs of Zuckerkandl in children aged more than one year contain both adrenaline and noradrenaline, and yet these organs lack direct contact with the suprarenal cortex.

In a further short study, it has been found that the relative noradrenaline content of the glands of various species do not appear to vary widely in different countries (Table 4).

Passing to the activities found in the cortices and medullae of different species, it is clear from Table 5 that the relative amounts of each amine in each component of the gland do not vary widely. Contamination of the cortex by small amounts of medulla is possible in some cases, but not in the pig or sheep, where complete separation is an easy task to perform. A relationship again exists between the relative amount of noradrenaline and the concentration of total amine found in the medulla; generally, the more active the medullary tissue, the less methylation occurs. This would suggest that the methylating process in some species is carried out only with difficulty, and possibly both amines are therefore secreted from the medulla in amounts which allow each to exert its full action in other parts of the body. Adrenaline may for example act as a specific hormone and have the general function of stimulating various metabolic processes in conditions of emotional stress. Noradrenaline may be considered as a reserve ready to be liberated in various emergency situations to support the actions of adrenergic nerves. While the proportions of adrenaline and noradrenaline vary to a large extent in different animal species, they seem to be relatively constant in the same species. This makes it difficult to believe that the same cells produce both compounds. Recent published reports (Euler and Folkow, 1953;

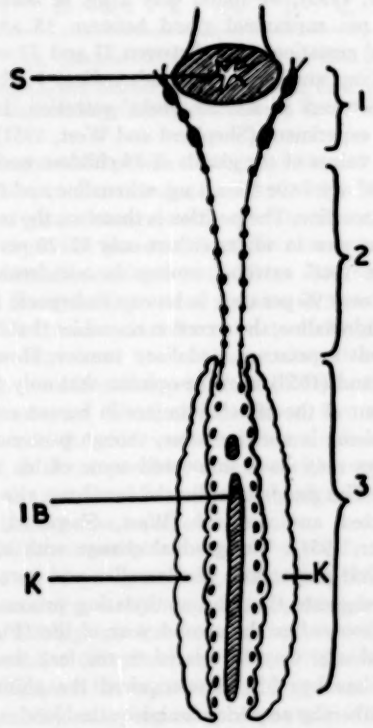

FIG. 5. LOCATION OF THE CHROMAFFIN TISSUE (black dots) IN THE DOGFISH

Numbers refer to chromaffin bodies used in making three separate extracts. S, stomach; IB, interrenal body; K, kidney.

TABLE 4

Catechol Amines in Suprarenal Glands of British and American Animals

(West, unpub.)

Animal	British			American		
	Total activity (mg./g.)	% Noradrenaline in the total	No. of Expts.	Total activity (mg./g.)	% Noradrenaline in the total	No. of Expts.
Guinea-pig	0.15	2	250	0.11	1	12
Rabbit	0.48	2	106	0.25	2	6
Mouse	1.00	25	22	0.92	30	12
Cat	0.97	38	48	0.81	50	6

TABLE 5

Catechol Amines in Cortex and Medulla of Suprarenal Glands of Several Species

(After Shepherd and West, 1953c; and West, 1953b)

Animal	Medulla		Cortex	
	Total activity (mg./g.)	% Noradrenaline in the total	Total activity (mg./g.)	% Noradrenaline in the total
Man	1.47	14	0.11	3
Sheep	3.25	39	0.14	29
Horse	4.00	20	0.20	20
Cow	5.25	27	0.60	33
Ox	5.50	24	0.55	27
Pig	8.00	50	0.21	38

Redgate and Gellhorn, 1953) in which a selective secretion of one or the other of the two compounds has been observed suggest specific adrenaline- and noradrenaline-producing cells. Moreover, specific cells in the suprarenal medulla show pigment formation on oxidation with potassium iodate in the same way as noradrenaline in vitro (Hillarp and Hökfelt, 1953).

The question whether noradrenaline is the sympathetic nerve transmitter in non-mammals cannot yet be answered conclusively. Analyses of organs from molluscs, teleosts, and insects have shown the presence of noradrenaline together with varying amounts of adrenaline, but a complicating factor in studies of this kind might be the presence of chromaffin cell groups which may contain the adrenaline and noradrenaline. In teleostian hearts and livers, the relative amount of adrenaline is high, while in posterior salivary glands of *Octopus vulgaris* and in insects and insect larvae, noradrenaline predominates. Ostlund (1953), for example, used earwigs, butterflies, mealworms, houseflies, and honey-bees for his studies. Interrenal tissue has not been identified in invertebrates, so that it is certain that the formation of adrenaline and its derivatives does not require cortical hormones in these species.

CATECHOL AMINES IN THE SUPRARENAL MEDULLA OF YOUNG ANIMALS

Holton in 1949 showed that tumors of the suprarenal medulla in man contain proportionately more noradrenaline than is normally found in glands obtained at post-mortem. The difference may be related to the fact that the tumor cells are relatively undifferentiated and thus may be more comparable with embryonic tissue than with adult tissue. This conclusion suggested that a study of the glands of young animals would be profitable, and hence investigations were undertaken in Dundee to discover what sympathomimetic amines or their precursors are present in the suprarenal medulla of embryonic, foetal, and young animals, including that of man. If such substances, or their relative amounts, differed from those found in the adult state, it might be possible by taking animals at different ages to correlate any change-over with a certain stage in development. In addition, another method might be provided of studying adrenaline formation in the body.

Human suprarenal glands. Throughout foetal life, the chromaffin tissue of the suprarenal medulla is scanty and immature. Even at full-term, it is composed in part of small dark undifferentiated cells (sympathicoblasts) and some immature chromaffin cells (phaeochromoblasts), and in foetuses of less than 20 to 22 weeks' gestation the majority of medullary cells are of these types. After birth, the medulla grows rapidly and is structurally similar to the adult gland before the end of the first year. By this time, the foetal suprarenal cortex has given way to the adult cortex and the scanty phaeochrome cells forming the rudimentary medulla have formed a more compact medullary mass. The pharmacological picture lags a little behind the maturation of the medulla as shown histologically, but nevertheless it has been proved that the amine of the foetus is not adrenaline but noradrenaline. We have been able to obtain both a faint chromaffin reaction and a positive test for noradrenaline in the suprarenal medulla of a foetus of 16 weeks' gestation (175 mm.). In a series of experiments (West, Shepherd, Hunter, and Macgregor, 1953), we found only 1 μg. of noradrenaline per suprarenal gland between 15 and 26 weeks' gestation, 2 μg. between 27 and 32 weeks' gestation, and 6 μg. (5 noradrenaline, 1 adrenaline) between 33 and 38 weeks' gestation. In another experiment (Shepherd and West, 1951), the mean values of the glands of 25 children under 70 days of age have been 4 μg. adrenaline and 60 μg. noradrenaline. The position is therefore the reverse of that seen in adults (where only 17–20 per cent of the total catechol amines is noradrenaline). Since over 90 per cent in human embryonic tissue is noradrenaline, the secretion resembles that found in adult suprarenal medullary tumors. However, Coupland (1953) is of the opinion that only 40–60 per cent of the catechol amines in human embryonic tissue is noradrenaline, though post-mortem changes may have influenced some of his specimens. The glands of older children have also been extracted and assayed (West, Shepherd, and Hunter, 1951). The gradual change with age to the adult proportions of adrenaline and noradrenaline suggests that the methylating process matures soon after the second year of life (Fig. 6). This change may be related to the fact that the baby has by this time acquired the ability to walk, thereby requiring an adequate blood supply to the skeletal muscles of the limbs. It is significant that adrenaline dilates the blood vessels supplying these muscles, whereas noradrenaline has no action or rather constricts them.

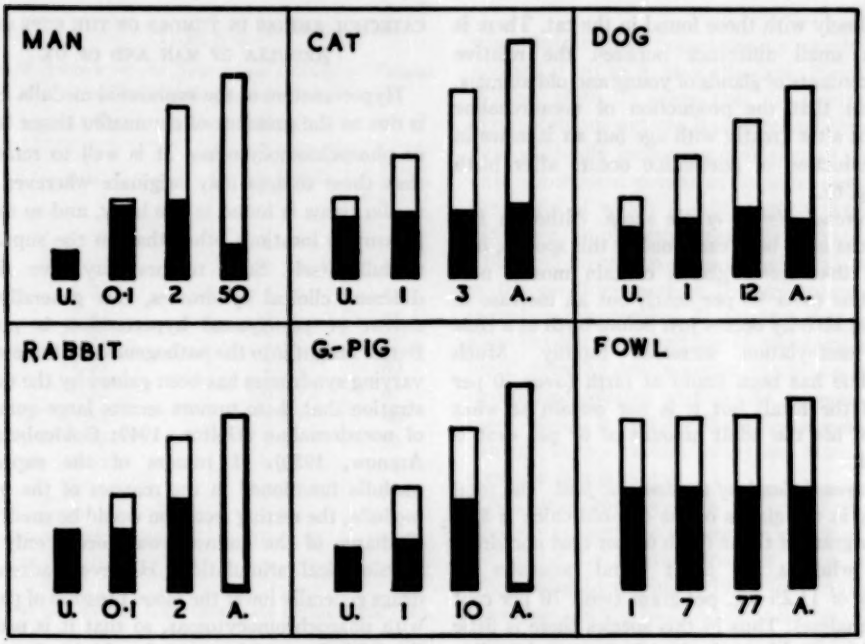

FIG. 6. THE CHANGE-OVER WITH AGE IN THE PROPORTION OF NORADRENALINE IN THE SUPRARENAL GLANDS

Noradrenaline, shaded area; adrenaline, clear area. In Man, U, in utero; other numbers refer to years of age. In cat, dog, rabbit, guinea-pig, and fowl, U, in utero; numbers refer to days of age; A, adult.

Cat suprarenal glands. The proportion of noradrenaline in the catechol amine fraction of extracts of glands obtained from foetuses in utero is higher than that found in the adult state (where it varies from 30 to 60 per cent). Even at the third day of life over 80 per cent remains as noradrenaline. The mean values for extracts of 20 glands at this stage have been 141 μg. adrenaline and 642 μg. noradrenaline per gram of fresh tissue (Shepherd and West, 1951). Since the adult glands exhibit wide variations from animal to animal, it is not possible to define with any certainty the age when maturity is reached as regards methylation in the suprarenal medulla.

Rabbit suprarenal glands. In very young foetuses (up to 17 days' gestation), the total catechol amine activity in the suprarenal glands is low (below 100 μg./g.) but is composed entirely of noradrenaline (Shepherd and West, 1951). In the last few days of life in utero, there is an increase in total activity and a beginning of adrenaline formation. By the second day of life, total activity has been increased to about twice that found in the adult gland, and large amounts of adrenaline are now present (297 μg. adrenaline and 603 μg. noradrenaline per gram of fresh tissue). By using a large series of over 120 animals, it has been possible to trace the change-over in the gland from entirely noradrenaline to a very high percentage of adrenaline, which is found in the adult state. Maturation of the medullary cells is complete histologically by about the 10th day of life, but pharmacologically it is not complete until the 20th day of life.

Guinea-pig suprarenal glands. In very young foetuses, the total catechol amine activity in the glands of the guinea-pig is low (less than 50 μg. per gram of tissue), and consists entirely of noradrenaline. Near or at term, a surprisingly large amount of adrenaline (over 250 μg. per gram of tissue) may be found (Shepherd and West, 1951). The change-over from the embryonic state producing noradrenaline to the adult state producing almost entirely adrenaline has been found to occur by about the 20th day of life. Maturation of the medullary cells is complete histologically by about the 6th day of life. Thus it appears that this maturation process is not directly related to the activity of the animal, for the young guinea-pig is mobile from the first day of life.

Dog suprarenal glands. Results in this species

agree closely with those found in the cat. There is only a small difference between the relative amine contents of glands of young and old animals. It seems that the production of noradrenaline does not alter greatly with age but an increase in the production of adrenaline occurs after birth (see Fig. 6).

Suprarenal glands of the sheep. Although few specimens have been examined in this species, it is certain that foetal glands contain mostly noradrenaline (over 90 per cent), but an increase in the total activity occurs just before birth at a time when methylation increases rapidly. Much adrenaline has been found at birth (over 30 per cent of the total) but it is not certain at what stage of life the adult amount of 67 per cent is reached.

Suprarenal glands of the domestic fowl. The total activity in the glands of the day-old chick is 8.25 mg. per gram of tissue (with 60 per cent noradrenaline), whereas the adult gland possesses an activity of 11.25 mg. per gram (with 70 per cent noradrenaline). Thus in this species there is little or no change with age in the relative noradrenaline content of the glands. This is well shown in Figs. 6 and 7, where the influence of age on the degree of methylation is illustrated for a few species. It may be mentioned that in the fowl the suprarenal medulla always forms a large fraction of the whole gland, and the ratio of cortical size to medullary size does not change markedly with age.

CATECHOL AMINES IN TUMORS OF THE SUPRARENAL MEDULLA OF MAN AND OF OX

Hyperfunction of the suprarenal medulla in man is due to the presence of chromaffin tissue tumors or phaeochromocytomas. It is well to remember that these tumors may originate wherever chromaffin tissue is found in the body, and so may be present in locations other than in the suprarenal medulla itself. Such tumors may give rise to different clinical syndromes, but generally persistent or paroxysmal hypertension is present. Better insight into the pathogenesis of these widely varying syndromes has been gained by the demonstration that these tumors secrete large quantities of noradrenaline (Holton, 1949; Goldenberg and Aranow, 1950). If tumors of the suprarenal medulla functioned in the manner of the normal medulla, the resting secretion would be small and a discharge of the amines would occur only upon physiological stimulation. However, adrenolytic drugs generally lower the blood pressure of patients with phaeochromocytomas, so that it is probable that this form of hypertension is due in part to the continuous secretion of the amines by the tumor. In Table 6 are recorded typical values for the catechol amine content of tumors of the suprarenal medulla of man. It will be seen that both the total activity and relative noradrenaline values greatly exceed those found in the control adult glands. There appears to be no correlation

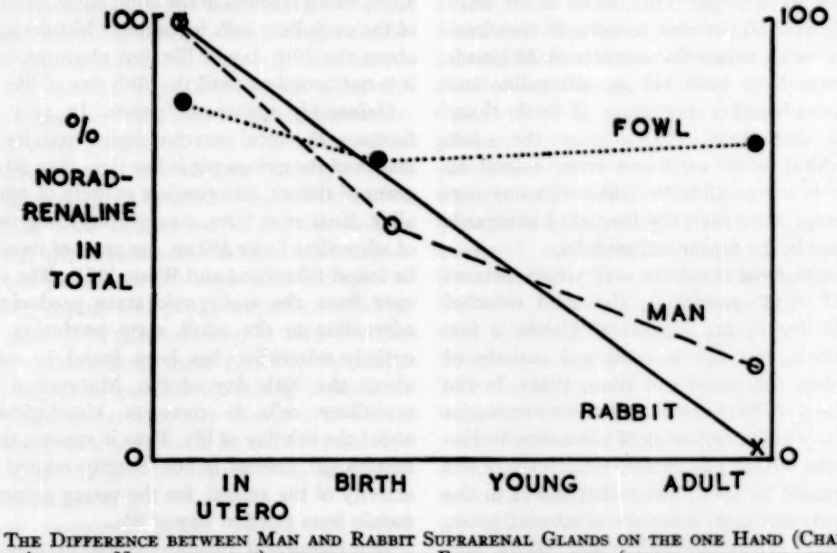

FIG. 7. THE DIFFERENCE BETWEEN MAN AND RABBIT SUPRARENAL GLANDS ON THE ONE HAND (CHANGE-OVER WITH AGE FROM NORADRENALINE), AND THOSE OF THE FOWL ON THE OTHER (LITTLE ALTERATION WITH AGE)

TABLE 6

Catechol Amines in the Suprarenal Glands of Patients with Phaeochromocytomas

(Assays completed in Dundee)

Date	Total Activity (mg./g.)	% Noradrenaline in the Total
11/51	1.36	98
2/52	3.39	97
4/52	1.51	44
7/52	10.66	88
11/52	1.46	77
12/52	2.50	80
1/53	6.00	67
6/53	1.50	50
3/54	3.31	80
3/54	9.00	72
3/54	3.20	93
156 control adult glands....	0.10–0.60	10–20

between the size of the tumor, its cellular pattern, and the symptoms produced (Symington and Goodall, 1953). Experimental attempts to produce sustained hypertension in rabbits by injecting adrenaline, noradrenaline, or mixtures of the two amines, have not met with much success, even when intravenous infusions are carried on for periods of up to 8 days (Blacket, Pickering, and Wilson, 1950). It seems that the natural history of phaeochromocytoma is paroxysmal hypertension with gradually increasing frequency of paroxysms until subsequent persistent hypertension develops the cause of which is still partly unknown. Improvement in operative mortality is due mainly to a better appreciation of the pathological physiology of the condition and to the prevention of post-operative hypotension. It appears that noradrenaline has the special ability of maintaining normal blood pressure levels under conditions of severe circulatory collapse and should be used in such cases. Since it usually increases coronary flow, damage in myocardial infarction after coronary occlusion is minimized.

Noradrenaline levels in the urine of cases of phaeochromocytoma are greatly increased whether the tumor be of suprarenal or extra-suprarenal origin. Engel and Euler (1950) first indicated the importance of this observation, and this estimation appears to offer the best available special method of diagnosis of phaeochromocytoma (Hamilton, Litchfield, Peart, and Sowry, 1953). No false positive result has been obtained so far, but it is premature to claim that no false negative has

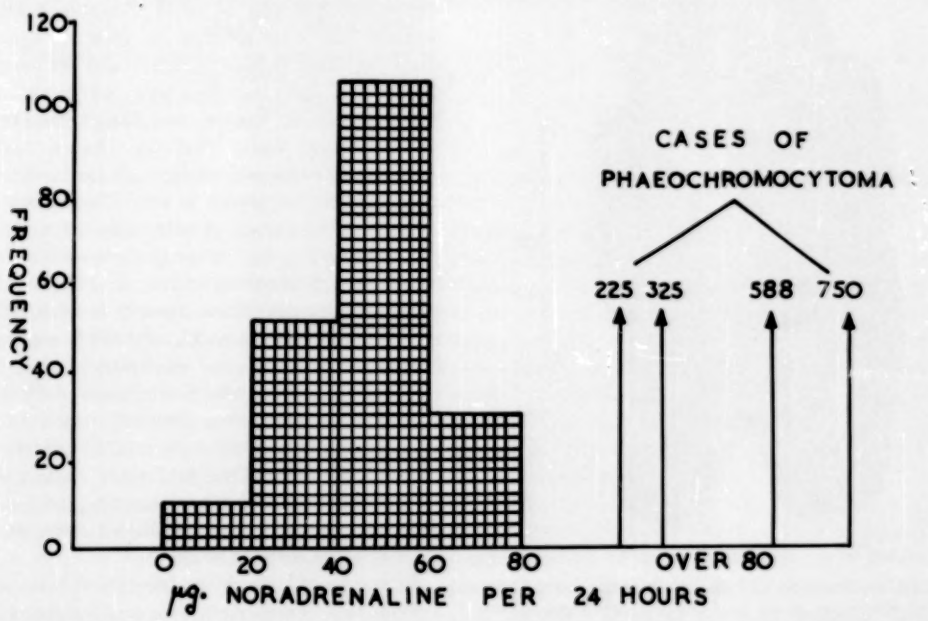

FIG. 8. FREQUENCY DISTRIBUTION OF NORADRENALINE EXCRETION IN 200 CASES OF HYPERTENSION
Values over 80 μg. per 24 hours generally indicate that a tumor of the suprarenal medulla (phaeochromocytoma) is present.

occurred (Fig. 8). Up to 3 mg. of noradrenaline a day (instead of the normal 10–80 μg.) may be excreted by such patients, and this quantity can be easily demonstrated by the cat blood-pressure test. The increased noradrenaline output is probably due to the fact that the cells of the tumor are relatively undifferentiated and thus may be more comparable with embryonic tissue than with adult tissue. There is usually good correlation between the relative amounts of the catechol amines in the urine and in the tumor. After removal of the tumor, the output of urinary catechol amines decreases to normal.

When the body is subjected to any form of severe circulatory stress, it is common to find an increase in the noradrenaline content in the urine of man. Conversely, any type of emotional stress results in an increase in the adrenaline content. It is customary therefore to try to avoid such types of stress when normal urinary specimens are taken prior to estimation of the catechol amines.

A few cases of suprarenal medullary tumors in the ox have been reported, and the pharmacological picture closely resembles that seen in man. One case recently examined in Dundee showed little change in the total catechol amine activity of the medulla from that normally found (see Table 5), but the percentage of noradrenaline was raised from 27 to over 90.

Mention should also be made of cases of Addison's disease, for in these patients the suprarenal cortex has atrophied. Relatively more noradrenaline appears in the medulla than is normally found (West, Shepherd, and Hunter, 1951), but the urinary excretion of noradrenaline usually lies within normal limits (Goldenberg, Serlin, Edwards, and Rapport, 1954).

FIG. 9. PHOTOGRAPH OF THE LOWER AORTA OF A CHILD AT BIRTH TO SHOW THE ORGANS OF ZUCKERKANDL LYING ON EITHER SIDE JUST ABOVE THE BIFURCATION AND OPPOSITE THE OPENING OF THE INFERIOR MESENTERIC ARTERY

CATECHOL AMINES IN ACCESSORY CHROMAFFIN TISSUE

It is well known that extra-suprarenal chromaffin tissue occurs in many animals. One of the largest congregations of such tissue in man is called the Organs of Zuckerkandl (Fig. 9). These para-aortic bodies are probably derived, like the sympathetic ganglia, from the neural crest, and they lie retroperitoneally at the level of the origin of the inferior mesenteric artery. They were first described by Zuckerkandl in 1901, and extracts of them were tested biologically for their adrenaline activities by Biedl and Wiesel in 1902. These bodies degenerate during the first year or so of life, and so far no function has been ascribed to them. A detailed study of their amine content and histological appearance has recently been undertaken by West, Shepherd, Hunter, and Macgregor (1953). These authors found that the Organs mature earlier than the suprarenal glands; at birth, only noradrenaline is present in both tissues, but the amount in the Organs greatly exceeds that in the suprarenals (Fig. 10). After birth, when the large foetal suprarenal cortex is being replaced by adult cortical tissue, adrenaline appears in both tissues at about the same rate (Fig. 11). This suggests a hormonal influence on methylation, but the evidence is not clear. As the Organs become more and more fibrosed, the chromaffin tissue in the medulla increases steeply its rate of growth. By the second year of life, the Organs contain only traces of amine (now adrenaline), and no activity has been found in tissues obtained from similar regions of the aorta in adults.

Several points should be mentioned here, since further work is indicated to ascertain the function of these Organs of Zuckerkandl. Firstly, there appears to be a relationship between the degree of

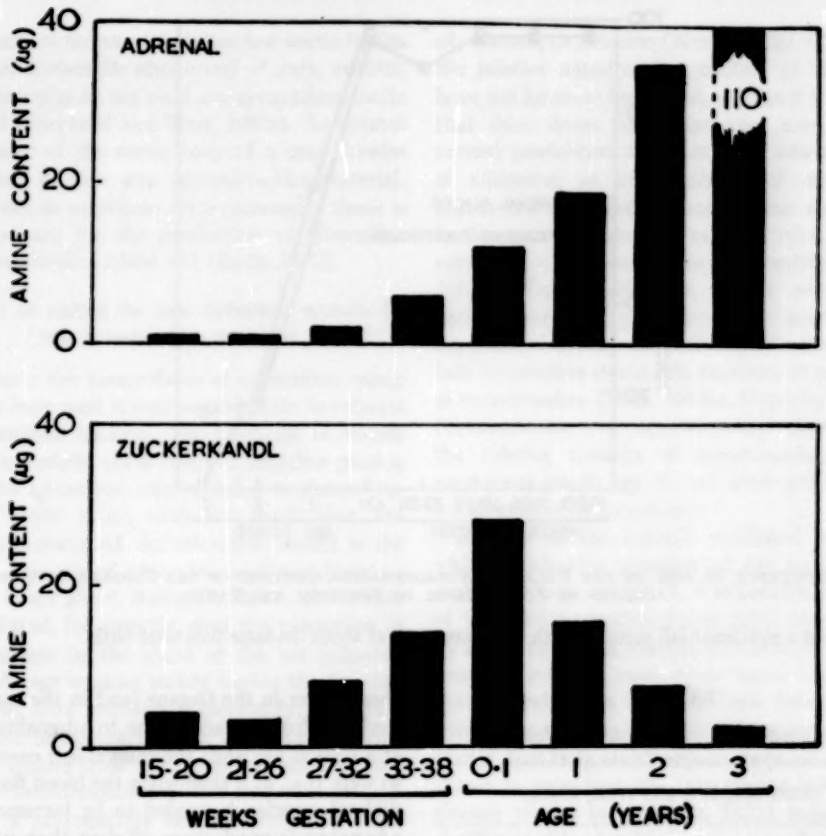

FIG. 10. INFLUENCE OF AGE ON THE ABSOLUTE AMOUNT OF PRESSOR AMINES IN ONE SUPRARENAL GLAND AND ONE ORGAN OF ZUCKERKANDL OF FOETUSES AND BABIES

Note that the Organ of Zuckerkandl reaches maturity at birth, when its amine content exceeds that found in the suprarenal gland.

chromaffin reaction in the Organs and the pressor amine content. This is of course not surprising, although it should again be stressed that substances other than pressor amines may give the color reaction. It is also of interest since Willier (1930) has shown that phaeochromocytes acquire the positive chromaffin reaction only when they come into close proximity to cortical cells. Coupland (1953) is also of the opinion that the presence of cortical tissue in proximity to, and sharing its blood supply with, chromaffin tissue determines the appearance of the catechol amines. However, the cells of the Organs of Zuckerkandl are completely separate from the suprarenal cortex, and hence it may be that activation is effected by some hormonal material. It would be interesting to find out the nature of this substance (possibly of cortical origin) which results in the cells acquiring a positive chromaffin reaction.

Secondly, it would be fundamental to determine the mechanism by which the cells of the Organs of Zuckerkandl undergo fibrosis at a time when the medullary cells are undergoing activation. It is tempting to suggest a hormone of pituitary origin as the controlling factor. Tumors of the Organs occur in adults, with consequent hypertension, and noradrenaline is present in large quantities both in the tumor and in the blood and urine. Again, it appears that a reversion to the immature or embryonic state occurs, just as it does in tumors of the suprarenal medulla.

Thirdly, we do not know the true function of these Organs. Since the Organs at birth contain large quantities of noradrenaline (a more potent pressor amine than adrenaline), it is possible that their secretion helps to maintain vascular tone until the sympathetic nerve endings and the suprarenal medulla are functionally mature. The

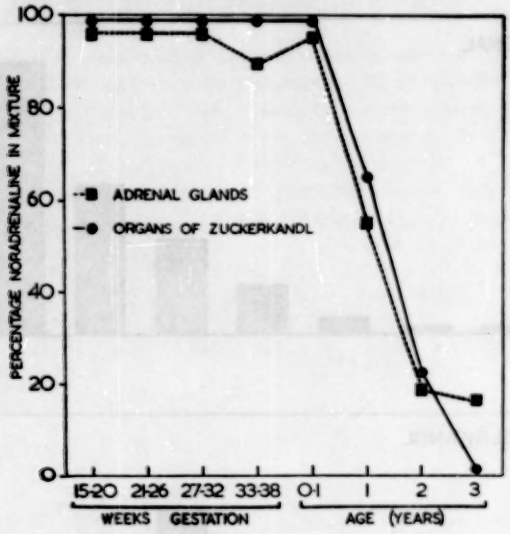

FIG. 11. INFLUENCE OF AGE ON THE RELATIVE NORADRENALINE CONTENT OF THE SUPRARENAL GLANDS AND ORGANS OF ZUCKERKANDL OF FOETUSES AND BABIES

Note that a significant fall occurs in both these structures at about the same time after birth.

TABLE 7

Catechol Amines (μg.) in Suprarenal Glands and Accessory Chromaffin Tissue of Animals

(After Shepherd and West, 1952a)

Species	Age	Suprarenals		Retro-peritoneal Tissue	
		Adrenaline	Noradrenaline	Adrenaline	Noradrenaline
Rabbit	In utero	0	4	0	4
	1 hour	4	5	0	12
	2 days	5	5	0	5
	Adult	92	1	0	0
Dog	In utero	2	4	0	5
	1 day	10	10	0	15
	9 days	50	25	0	10
	Adult	500	200	0	0
Cat	In utero	3	10	0	3
	12 hours	16	70	0	25
	1 day	20	70	0	10
	Adult	120	80	0	0
Guinea-pig	In utero	0	5	0	8
	1 hour	5	5	0	10
	2 days	20	5	0	3
	Adult	71	1	0	0

change-over in the Organs (and in the suprarenal medulla) from noradrenaline to adrenaline occurs at a time in life when the child is just commencing to walk (i.e., at a time when the blood flow to the skeletal muscles is needed to be increased), and adrenaline is much more efficient than noradrenaline for this action. As the structure and blood supply of the Organs of Zuckerkandl is very similar to that of the suprarenal medulla, noradrenaline may be discharged into the circulation of the foetus in the last weeks of intrauterine life. If this occurs, then their secretion must exert a profound influence on the vascular tree of the foetus and new-born infant.

In young animals, accessory chromaffin tissue also occurs in many parts of the body. Para-aortic bodies in the rabbit, guinea-pig, cat, and dog have been found to contain considerable amounts of noradrenaline (Shepherd and West, 1952a), and in many cases the quantity exceeds that in the suprarenal medulla. Again, it may be that these para-aortic bodies perform some autonomic function early in life, possibly helping to maintain blood pressure. As the animal grows older and the suprarenal medulla matures, so the amine content of this accessory tissue declines (Table 7). Again, it would be interesting to discover the mechanism by which this decline is brought about.

Extracts of the carotid bodies and aortic bodies (so-called chromaffin structures) of cats, rabbits, and guinea-pigs do not yield any sympathomimetic material (Shepherd and West, 1952a). An extract of a tumor of the aortic body of a cow likewise has failed to give any adrenaline-like material. This is not so surprising since chromaffin tissue is not necessary for the production of adrenaline and noradrenaline (Abel and Macht, 1912).

EFFECTS OF DRUGS ON THE CATECHOL AMINES OF THE SUPRARENAL MEDULLA

To study the biosynthesis of adrenaline, many workers have used injections of insulin to exhaust the suprarenal medulla. The discharge of amines from the medulla (as a result of impulses passing along the splanchnic nerves) helps to restore the normal blood sugar, with the result that the gland is overworked. An alteration results in the relative amounts of adrenaline and noradrenaline present in the gland. Burn, Hutcheon, and Parker (1951) found, for example, that the proportion of noradrenaline in the gland of the rat following insulin dosage remains steady during the first few hours but later increases considerably. This suggests that initially there is a constant liberation of both amines from the suprarenal medulla, but later the noradrenaline which is formed is methylated to a progressively smaller extent. In other words, noradrenaline is a precursor of adrenaline in the rat, and its supply after the gland is exhausted by insulin is restored more rapidly than it can be methylated to form adrenaline. A selective deficiency of adrenaline is produced. If two types of secreting cell exist in the adrenal medulla, insulin may partially deplete the adrenaline-secreting cells but may have little action on the noradrenaline-secreting cells. West (1951b) carried out similar experiments in rabbits and found that traces of noradrenaline (not normally determined in this species) are present in the suprarenal glands during the first few hours following insulin administration, but later noradrenaline is not detected. In the pigeon, the injection of insulin releases both adrenaline and noradrenaline from the suprarenal glands, whereas in the fowl only noradrenaline is released (West, 1951a). Thus it is possible that the suprarenal glands of different species respond in a different way when subjected to insulin depletion.

Suprarenal exhaustion in rabbits, guinea-pigs, and rats has also been induced by doses of thiouracil, alloxan, or nicotine (West, 1952a). Changes in the relative noradrenaline content of the glands have not however been great, so that it is probable that these drugs fail to influence markedly the normal production of the catechol amines. Doses of ethionine, an antimetabolite of methionine, reduce the amount of noradrenaline methylated in the suprarenal gland of rats and mice, but precursors of noradrenaline are not identified (West, 1953a). Desoxypyridoxine, which acts as an antimetabolite of pyridoxine, the coenzyme of dopa decarboxylase (see under Biosynthesis), also fails to produce detectable amounts of precursors of noradrenaline (West, 1953a). Hypophysectomy, thyrotoxicosis, and thyroidectomy likewise alter the relative amount of noradrenaline in the suprarenal gland, but do not allow precursors of noradrenaline to accumulate.

In view of the recently published reports in which a selective secretion of one or the other amine has been suggested, it is possible that most of the results reported above could be explained by assuming specific adrenaline- and noradrenaline-secreting cells. In man, there seems little doubt that hypoglycemia resulting from insulin dosage releases much more adrenaline than noradrenaline (Euler and Luft, 1952). Conversely, it has been shown in cats that the intravenous injection of glucose results in a rise in blood sugar and a significant reduction in the secretion of adrenaline into the suprarenal vein (Dunér, 1953).

CATECHOL AMINES IN THE BLOOD OF THE SUPRARENAL VEIN

It has been known for quite a time that stimulation of the splanchnic nerve in animals produces effects which correspond well with those following intravenous injections or infusions of adrenaline. However, certain discrepancies were sometimes apparent, and the work of Euler in 1946 showed that these actions could be accounted for by assuming that varying amounts of noradrenaline are liberated simultaneously with the adrenaline from the suprarenal gland. For example, West (1949) showed that stimulation of the splanchnic nerve in cats produced effects which corresponded with those produced by intravenous infusions of adrenaline, a mixture of noradrenaline and adrenaline, or noradrenaline, depending entirely on the length of time the nerve had been sectioned before being stimulated. Methylation of noradrenaline could thus be reduced, so altering the nature

of suprarenal sympathin. A further advance was made by West (1950a) when blood from the suprarenal vein of a stimulated cat was injected into the arteries supplying the nictitating membrane and nonpregnant uterus of a donor cat (two very sensitive test organs). The results at the beginning of each experiment corresponded well with those following intra-arterial injections of adrenaline, but after an hour or more of continued stimulation these effects corresponded with those following injections of a mixture of adrenaline and noradrenaline. In other words, when the splanchnic nerve is stimulated continuously, relatively more noradrenaline than adrenaline is liberated from the suprarenal gland. Bülbring and Burn (1949a) had previously shown by other tests that both amines were liberated from the gland on stimulation of the splanchnic nerve, although relatively more noradrenaline was secreted on prolonged stimulation. Gaddum and Lembeck (1949) also showed that noradrenaline as well as adrenaline was secreted into the suprarenal vein when the splanchnic nerve in cats was stimulated. In rabbits, West (1950b) found that adrenaline was present in the plasma in the suprarenal vein following brief stimulation of the splanchnic nerve, but chronic stimulation resulted in the appearance of noradrenaline in the plasma, and this amounted to 30 per cent of the total catechol amines.

Recently, Mirkin (1953) has found that the material released from the suprarenal medulla does not resemble on a percentage basis the sympathin obtained from other tissues. Assays of suprarenal venous blood in cats contained 70 per cent adrenaline, whereas in rabbits it amounted to 90 per cent. In other tissues, the amount rarely exceeded 5 per cent of the total catechol amines.

It is now widely accepted that provided the sympathetic innervation is intact adrenaline and noradrenaline are discharged continuously from the suprarenal medulla of many species. In the cat, for example, Kaindl and Euler (1951) found a basal discharge of total catechol amines of 0.03–0.06 μg./kg./min. The venous blood was collected from the left suprarenal and assayed biologically. This secretion may however be considerably altered by various experimental procedures. Direct electrical stimulation of the splanchnic nerve produces a hundredfold increase of the mixed secretion. Reflex stimulation resulting from electrical excitation of the central end of the cut sciatic nerve or the brachial plexus increases the adrenaline (but not the noradrenaline) output (Euler and Folkow, 1953), and similar effects have been noted during emotional stimuli, in hypoglycaemia, and after trauma. The noradrenaline output appears to be increased in conditions involving some kind of circulatory stress, such as activation of the carotid sinus pressor reflex, or heavy muscular work. After electrical stimulation of the hypothalamus in cats, the output can be varied depending on the site of stimulation (Euler and Folkow, 1953). When the electrodes are located in the anterior hypothalamus just posterior to the optic chiasma, noradrenaline is said to be preferentially liberated, whereas when the electrodes are immediately before and behind the mammillary bodies adrenaline is produced in larger quantity (Redgate and Gellhorn, 1953). It may be therefore that the secretion of the individual hormones is activated by specific nerves, and this differentiated secretion, depending on the functional requirements of the organism, suggests that both adrenaline- and noradrenaline-producing cells may be present. Already it has been mentioned that specific cells in the suprarenal medulla show pigment formation on oxidation with potassium iodate in the same way as noradrenaline in vitro (Hillarp and Hökfelt, 1953). These authors used the glands of the rat, cat, cow, dog, sheep, horse, guinea-pig, and rabbit, and showed fair agreement between the histological picture based on this reaction and the relative noradrenaline content of the glands when assayed biologically.

BIOSYNTHESIS AND METABOLISM OF THE CATECHOL AMINES

The way in which noradrenaline is formed in the body is not yet known with certainty. The evidence presented earlier of the occurrence of large amounts of noradrenaline in the suprarenal glands of the young of most species and in glands of adults with phaeochromocytoma supports theories already put forward that this amine is one of the precursors of adrenaline. Bülbring and Burn (1949b), for example, obtained evidence of the conversion of noradrenaline to adrenaline in the perfused suprarenal gland of the dog, by observing a disappearance of noradrenaline and a corresponding increase in the amount of adrenaline in the perfusate. When minced suprarenal tissue was incubated with adenosine triphosphate and a methyl donor, noradrenaline was converted into adrenaline; the conversion was most vigorous in tissue

prepared from glands stimulated through the splanchnic nerve beforehand (Bülbring, 1949).

The discovery that animal organs contain an enzyme capable of decarboxylating dihydroxyphenylalanine (DOPA) into hydroxytyramine (dopamine) indicated one possible route of formation of noradrenaline (Holtz, Heise, and Lüdtke, 1938). This enzyme, L-dopa decarboxylase, is specific for L-dopa and occurs in the suprarenal and renal tissue of many warm-blooded animals (Langemann, 1951). Dopamine seems to occur regularly in urine and has been found in the suprarenal glands of a few species such as sheep and ox (Goodall, 1951; Shepherd and West 1953c). Ostlund (1953) has recently identified it in concentrated extracts of various insects. However, the process whereby the introduction of the hydroxy group in the sidechain of dopamine is effected still remains unknown, although it is known to occur in vitro.

When rats are fed on a diet deficient in pyridoxine (the coenzyme), the amount of L-dopa decarboxylase in the liver is greatly diminished, and, given insulin to deplete the catechol amine content of the suprarenal gland, they appear to lack the ability to replenish the store of pressor amines in the gland. When insulin is given to normal rats, only DOPA among many likely competitors can rapidly restore the pressor amine content of the suprarenal medulla (Arman, 1951). Thus it is possible that the enzyme, L-dopa decarboxylase, is part of the normal mechanism of noradrenaline formation, a hypothesis first put forward by Blaschko in 1942. Many groups of workers in different parts of the world are busy working on inhibitors of DOPA decarboxylase in the hope that accumulation of DOPA will occur. Related compounds seem a favorable line of research, as also are derivatives of phenylalanine.

Since dihydroxyphenylalanine has not been conclusively demonstrated so far in extracts of suprarenal glands, it is wise to consider other pathways in the biosynthesis of adrenaline (Fig. 12). One such scheme involves the formation of tyramine and *p*-hydroxyphenylethanolamine (*p*-norsynephrine). Both of these substances have been found occurring naturally (in the octopus), though generally not in the suprarenal gland or chromaffin tissue (Erspamer and Boretti, 1951). It is certainly of interest that the latter substance (as well as its meta-analogue) can be converted into noradrenaline under the influence of ultraviolet irradiation in the presence of air (Shepherd and West, 1952b), whilst the former substance

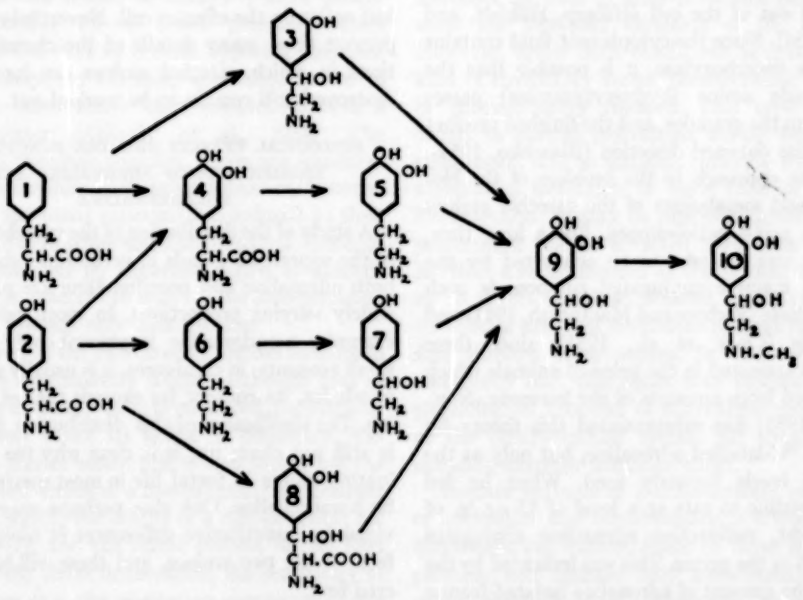

FIG. 12. POSSIBLE ROUTES OF FORMATION OF ADRENALINE FROM AMINO-ACIDS

1, phenylalanine; 2, tyrosine; 3, meta-norsynephrine; 4, DOPA; 5, hydroxytyramine (dopamine); 6, tyramine; 7, para-norsynephrine; 8, dihydroxyphenylserine; 9, norandrealine; 10, adrenaline.

changes to hydroxytyramine (dopamine) under similar conditions. Tyramine could also be an important step between tyrosine and *p*-hydroxyphenylethanolamine in this scheme of synthesis. Dihydroxyphenylserine has not so far been found occurring naturally; it is the amino acid corresponding to noradrenaline and can be decarboxylated by extracts of guinea-pig's kidney (Blaschko, Burn, and Langemann, 1950). West (1953b), in a critical study of these precursors, failed to obtain clear evidence of their occurrence in mammalian tissue. The lactyl derivatives of the catechol amines have been found by Crawford (1951) in extracts of suprarenal tumors of man, and they might be the means whereby the gland stores the active material. West (1953c) has confirmed their presence chromatographically and their weak biological potency.

It has been reported recently that the greater part of the pressor amines is concentrated within the particulate fraction of the cells of the ox suprarenal medulla (Hagen, 1954). They are intracellularly localized within specific granules which fill the entire cytoplasm of the cells. These specific catechol-containing structures in the rat release adrenaline during stimulation of the suprarenal medullary cells by insulin, and thus the amine is rapidly transported through the cytoplasm and out of the cell (Hillarp, Hökfelt, and Nilson, 1954). Since the cytoplasmic fluid contains the L-dopa decarboxylase, it is possible that the freshly made amine (hydroxytyramine) passes on to or into the granules, and the finished product leaves in the outward direction (Blaschko, 1954).

A further approach to the problem of the biosynthesis and metabolism of the catechol amines is possible using radioisotopes. For a long time, adrenaline was thought to be converted by the body into inactive conjugated compounds such as the sulphate (Richter and MacIntosh, 1941) and glycuronide (Clark et al., 1951), since these conjugates appeared in the urine of animals which had ingested large amounts of the hormone. Now, Schayer (1951) has substantiated this theory by the use of ^{14}C-labelled adrenaline, but only at the high dose levels formerly used. When he fed α-^{14}C adrenaline to rats at a level of 45 μg./g. of body weight, radioactive adrenaline conjugates were found in the urines. This was indicated by the fact that the amount of adrenaline isolated from a hydrolyzed sample was about 40 times the amount found free. When a more nearly physiological dose was given intravenously (e.g., 0.05 μg./g. of body weight), only traces of free adrenaline and its conjugates were excreted in the urine. Later, Schayer and his colleagues (1952) found that the α- and β-^{14}C-labelled adrenalines were eliminated in the urine four hours after injection, whereas the N-methyl-^{14}C-labelled adrenaline was only half eliminated in the similar period of time. This led Schayer to the conclusion that one of the metabolic pathways involved removal of the methyl group, and that amine oxidase is involved in the degradation of adrenaline to yield methylamine. The metabolic breakdown products believed to arise through the action of amine oxidase disappeared from the urine when amine oxidase was inhibited by 1-isonicotinyl-2-isopropyl-hydrazine (Schayer and Smiley, 1953). Thus in the living organism, the inactivation of some of the adrenaline is due to the action of amine oxidase. This enzyme we now know to be located in the mitochondria of cells, including those of the suprarenal gland, so that part at least of the catechol amines that is destroyed by amine oxidase penetrates the cell wall and passes into the cytoplasm. Thus we are slowly gaining knowledge about interrelations between chemical changes and the spatial distribution of active substances, and this will assist in defining the precise location of the sites of biological action in the effector cell. Nevertheless, at the present time, many details of the chemical reactions in which catechol amines are formed and destroyed still remain to be worked out.

BIOLOGICAL EFFECTS AND THE FUNCTIONAL SIGNIFICANCE OF ADRENALINE AND NORADRENALINE

A study of the distribution of the catechol amines of the suprarenal glands in vertebrates shows that both adrenaline and noradrenaline are present in widely varying proportions. In most rodents, for example, noradrenaline is present only in very small amounts; in carnivores, it is usually plentiful; in whales, its content far exceeds that of adrenaline. The significance of this distribution in adults is still not clear; nor is it clear why the predominating amine in foetal life in most species should be noradrenaline. One clue perhaps may be provided by quantitative differences in biological effects of the two amines, and these will be considered first.

As far as circulation is concerned, it is well known that adrenaline produces tachycardia in

man and an increase in cardiac output. Noradrenaline, on the other hand, produces bradycardia as a result of a reflex vagal action (Barcroft and Konzett, 1949; Swan, 1949), with little or no effect on cardiac output. Physiological amounts of adrenaline have hardly any effect on the diastolic pressure, whereas correspondingly small doses of noradrenaline (0.1–0.3 μg./kg./min.) produce an increase in both diastolic and systolic pressures. Hence it may be concluded that in man adrenaline is a cardiac accelerator agent but not a general vasoconstrictor; in fact, adrenaline actually increases blood flow through tissues such as skeletal muscle. Noradrenaline is said to be almost exclusively a vasoconstrictor and pressor agent. A word of warning should be sounded here, however, since another school of thought considers that both amines are more or less qualitatively identical in action, when results on animals are taken into account (Zanetti and Opdyke, 1953). For example, both exert a direct vasodilator action on isolated coronary arteries and intestinal vessels of the cat (Burn and Hutcheon, 1949), and on the vessels of the rabbit ear during perfusion with 2-benzylimidazoline. The fact that noradrenaline is usually a more potent pressor agent than adrenaline in the unanesthetized dog does not mean that the former is always a more potent vasoconstrictor, for a blood pressure record represents the sum of several opposing agencies. In the kidney, for example, adrenaline is two to ten times more active than noradrenaline as a vasoconstrictor (Ahlquist et al., 1954). The problem is therefore complex. There are quantitative and sometimes qualitative differences between man and the usual experimental animals in their response to adrenaline and noradrenaline. Generalizations obtained by experimentation in animals should be transferred to man for the interpretation of clinical findings only with caution.

The effects of the two catechol amines on smooth muscle are qualitatively similar, although that of adrenaline is usually more pronounced, particularly in situations where its action is inhibitory. Examples of tissues where this is well shown are the intestine and uterus of a non-pregnant cat (Barger and Dale, 1910), the uterus of a non-pregnant rat (West, 1947), and the rectal caecum of the fowl (Euler, 1948). After denervation, the sensitivity of some tissues (e.g. the nictitating membrane of the cat) to noradrenaline is greatly increased whilst that to adrenaline is only slightly affected (Bülbring and Burn, 1949a). This may be due in part to a decline in the amine oxidase content of the membrane.

Adrenaline is usually much more powerful than noradrenaline in its effects on metabolic processes. This difference (mostly ten-fold) may be seen, for example, in the action on the total oxygen consumption in man (Goldenberg et al., 1948), on the glucose output of the liver (Holtz and Schümann, 1949; Schümann, 1949), on lactic acid formation and potassium shifts, as well as on white blood cell counts and adrenocortical ascorbic acid. It is also more potent in inhibiting autonomic ganglia in dogs and the peristaltic reflex in guinea pigs (McDougal and West, 1954).

Thus the functional differences between the two amines are (a) the pronounced vasoconstrictor action of noradrenaline, and (b) the stronger metabolic effects of adrenaline. A study of their release from the suprarenal medulla and adrenergic nerves reveals that under such conditions as involve some kind of emotional stress, adrenaline is predominantly released. Examples are in aircraft pilots during flying, passengers prior to flying, patients with hypoglycaemia or pain or trauma, or patients suffering from infectious diseases or various surgical procedures. Adrenaline rapidly increases the rate of most metabolic processes to meet the increased demands of the organism. However, under such conditions as involve some kind of circulatory stress, noradrenaline is said to be predominantly released. This type of stress occurs in normal individuals during heavy muscular work, and in patients suffering from recent myocardial infarction or some form of essential hypertension. It may be preceded, however, by a preferential release of some adrenaline designed to effect a redistribution of the cardiac output, so as to divert blood to skeletal muscle while the constrictor action of adrenaline reduces the volume flow through other organs. In keeping with its emergency role, this again may indicate another physiological function of adrenaline—preparation of the cardiovascular system for situations demanding extreme muscular effort.

Another example of a differentiated production of adrenaline and noradrenaline is offered by the chromaffin cell tumors. Some of these apparently produce and contain only noradrenaline, while others produce both compounds, noradrenaline always appearing in relatively large amounts. It may be that tumors develop from the noradren-

aline-secreting cells (if they are separate). Tumors containing only adrenaline have not so far been observed.

It is well recognized that the continual increase in the anatomical approximation of the two components of the suprarenal glands, from complete separation in dogfish and sharks to the closest approximation in man, is likely to have some physiological significance. The cortex and medulla may form a functional entity, cortical hormones being secreted for transference to the central medulla. There is evidence, too, that adrenaline lowers the blood level of cortisone and appears to increase the consumption of cortisone in the target organs. The suggestion that the suprarenal cortex manufactures a coenzyme for L-dopa decarboxylase and is thus essential for the synthesis of the pressor amines of the medulla has not been proved, and we are still far from understanding the cortico-medullary relationship in the gland.

An interesting finding relates to the anencephalic monster in man. In such monsters at birth, the pituitary is deficient or lacking and the foetal suprarenal cortex is mainly absent, being replaced by adult cortical cells. Hunter, Macgregor, Shepherd, and West (1952) found that the suprarenal medulla, however, contains many times the pressor activity found in the normal embryo at birth, despite the smallness of the gland (about one-tenth the weight of normal). This means that there is a mature cortex and a highly active medulla, a picture corresponding to that found in a child of two or three years. There is one exception, however, in this analogy—the relative amount of noradrenaline. In the normal child of two, this amount is of the order of 20 per cent of the total catechol amines, whereas in the anencephalic at birth it is 100 per cent. Can this mean that production of active suprarenal medullary cells is stimulated by the secretion of active adult cortical cells, yet maturation (i.e., methylation) needs the secretion of the pituitary gland? It is possible, since noradrenaline is also the only amine found in the Organs of Zuckerkandl of the anencephalic child. Further work is obviously necessary to elucidate this problem and to decide whether special methylating cells exist.

Lastly, much evidence has accumulated indicating that the resistance to stress displayed by animals possessing suprarenal glands is due in large part to hormones elaborated by the cortex. This has tended to obscure the important role of the medullary secretion in increasing the resistance of the adrenalectomized animal to stressor agents (such as globin or dextran) which induce reactions strikingly similar to, if not identical with, those of anaphylaxis. There can be no doubt now that both components of the gland secrete hormones which increase this resistance of the animal. And this is a unique situation considering the difference in origin of the two portions and the chemical differences in their secretions. No adequate explanation has been forthcoming so far to account for the striking similarity in this protective property. Identical responses can obviously be effected by quite different means.

SUMMARY

It is well established that most suprarenal glands contain both adrenaline and noradrenaline, though their relative amounts vary widely. There is no obvious reason for this variation. Suprarenal cortical or pituitary hormones may be some of the factors determining the degree of both methylation and maturation in chromaffin structures.

Recent evidence indicates that a differentiated secretion of adrenaline and noradrenaline from the suprarenal medulla depends on the functional requirements of the organism. Thus, noradrenaline is released during conditions which involve primarily circulatory needs, while adrenaline is primarily engaged in adjustments of certain metabolic functions and the regional blood supply to organs. Adrenaline thus complies with the definition given by Cannon as an emergency hormone.

It is possible that noradrenaline is selectively stored in certain specific cells in the suprarenal medulla. The cytological selectivity suggests that noradrenaline is not only a precursor of adrenaline but also an independent hormone, helping to maintain vascular tone.

The biosynthesis of these catechol amines in the suprarenal gland is not yet known with certainty. It is possible that it is linked with protein metabolism.

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PHYSIOLOGY AND PHYLOGENY IN THE WATER MOLDS—A REEVALUATION

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IN 1950, an attempt was made (Cantino, 1950) to determine if physiological criteria could be utilized, even if only in some small measure, to help modify, corroborate, or further extend preexisting concepts regarding phylogenetic relationships among aquatic Phycomycetes. However, the scarcity of metabolic investigations then available rendered it impossible to ascertain what bearing, if any, cellular physiology and biochemistry might play in such an undertaking. It therefore became necessary to resort to, and to place the main emphasis upon, the results of nutritional investigations. Even with this limitation, the relative lack of definitive information on the nutrition of the Chytridiales rendered conclusions about the uniflagellate water molds somewhat tentative and premature. Nevertheless, an integration of the data then available led to the suggestion that differences in synthetic capacities among the main orders of saprophytic water molds were rather consistently well defined.

Since that time, the nutrition of some of these fungi has been reexamined, other genera and species have been newly investigated, and finally, reports on the cellular metabolism and biochemistry of cell-free preparations have begun to appear at an accelerating pace. In this light, therefore, it seems appropriate to survey once again the relation between synthetic capacities and phylogeny in the water molds, and thus to extend, or to modify accordingly, previously published notions on this subject. The following report is the result of such a survey.

It would be inappropriate to cite once again all of the references to investigations which appeared prior to 1950. The interested reader can find all such pertinent data in the earlier appraisal (Cantino, 1950). For ease of presentation and interpretation, this report is subdivided into three sections as follows:

(1) Citation of new or heretofore undocumented references to nutritional investigations of aquatic Phycomycetes, together with a brief consideration of their bearing on current concepts regarding the relation between nutrition and phylogeny.

(2) Citation of pertinent references on the cellular metabolism and biochemistry of aquatic Phycomycetes, and a selection and discussion of those data which lend themselves to a further evaluation of phylogeny.

(3) Finally, an overall summary of the relation between synthetic capacities and phylogeny in aquatic Phycomycetes, based upon the incorporation and integration of the foregoing data into the basic framework of the phylogenetic scheme of 1950.

NUTRITION

Chytridiales. According to Haskins and Weston (1950), *Karlingia* (*Rhizophlyctis*) *rosea*, which actively decomposes cellulose, grows vigorously on glucose and cellobiose but not on sucrose. Apparently, both nitrate and ammonium salts serve as sole sources of nitrogen for growth. On the other hand, Crasemann (1954) reports that both *Macrochytrium* (which decomposes cellulose), and *Chytridium* (which grows on chitinous substrata but which cannot decompose cellulose) (a) utilize a variety of sugars, and (b) are completely dependent upon an exogenous supply of thiamine for growth. However, whereas *Chytridium* utilizes ammonium compounds, but not nitrates, as sole sources of nitrogen for growth, *Macrochytrium* can use either one.

Nutritional studies of the chytrids have been, and continue to be, urgently needed. Consequently the foregoing contributions, although few in number, will play an important role in current and future attempts to evaluate relationships in an area where any conclusions were previously ad-

mittedly premature. But, with the growing interest in the vital role that physiological criteria will play in phylogenetic considerations, it is also necessary to consider seriously recent, justified pleas (e.g., Lilly and Barnett, 1951, 1953; Machlis, 1953a; etc.) for more critical, definitive, careful approaches to nutritional investigations of the fungi, and for more thoughtful interpretations of the results derived therefrom. Such considerations are particularly applicable at this point; any phylogenetic scheme must stand or fall upon the validity of the data which constitute the framework of such a scheme, and our knowledge of the Chytridiales represents the weakest link in this framework.

Prior to 1950, virtually all so-called chitinophylic chytrids were thus characterized because they evidently *grew* on chitinous substrata. But there is hardly an instance where it can be concluded from the literature that chitin, as such, is utilized as a carbon source, let alone the sole carbon source, for growth. If rigid standards are to be maintained in this reevaluation of phylogeny in aquatic Phycomycetes, then it must be concluded that to this day it still remains impossible to state with any reasonable degree of certainty that any chytrid utilizes chitin as the sole source of carbon for growth. Even Crasemann's *Chytridium* did not grow on unbleached chitin; it grew only on crab exoskeleton, hardly a pure compound! Therefore, although there is no question that certain chytrids can decompose and use cellulose as a sole carbon source for growth (e.g. references in Cantino, 1950; Haskins and Weston, 1950; Reese and Levinson, 1952; Crasemann, 1954; etc.) it cannot be concluded with certainty that they can do so on chitin.

Crasemann's investigations may also serve, at this point, to illustrate a second pitfall that must be avoided, but into which other mycologists have fallen. On the basis of evidence then available, it was assumed (Cantino, 1950) as a working hypothesis that the chytrids were the most primitive of the uniflagellate Phycomycetes because, among other reasons, they could reduce sulfate and use it as the sole source of sulfur for growth. As yet, there is no reason to modify this point of view. But, in view of the relatively small quantities of sulfur required by the water molds (e.g., *Blastocladiella*, Barner and Cantino, 1952; *Allomyces*, Ingraham and Emerson, 1954; etc), like most other microorganisms, it is not enough to assume that sulfate is utilized simply because of negative evidence. Small quantities of organic, reduced sulfur compounds can be detected chromatographically in many organic, and even some inorganic, reagents used in the preparation of synthetic culture media. Thus, it cannot be concluded with certainty that Crasemann's *Chytridium* and *Macrochytrium* can use sulfate simply because growth occurred in its presence when growth was not tested, on the same basal medium, in its absence.

With these reservations in mind, Crasemann's nutritional investigations of the chytrids remain the most quantitative and the most precise ones available at this time. Her data can be used to advantage for constructive modification of earlier concepts of the nutrition of the Chytridiales.

First, it cannot be denied that at least some members of the chytridiaceous complex have lost the capacity to synthesize thiamine. The best approximation, then, is that the Chytridiales are heterogeneous in this respect, some having lost and others having retained the primitive potentiality for biosynthesis of this vitamin during growth. Similarly, some chytrids have lost, while others have retained, the capacity to use nitrate as the sole source of nitrogen for growth.

Second, on the basis of Whiffen's generalization, a correlation had been drawn (Cantino, 1950) between the ability of chytrids to decompose cellulose and their presumed loss of capacity to grow vigorously on sugars other than cellobiose or glucose. In view of Crasemann's findings, this speculation must now be discarded in so far as it is not of general applicability. By the same token, as well as the comments offered above regarding chitin utilization, it is also necessary to dispel any notion (Cantino, 1950) that chitin decomposition, too, may be associated with a loss of capacity to grow vigorously on sugars other than glucose.

Third, because inadequate control of the reaction of the medium in Whiffen's studies may have been a limiting factor (cf. Crasemann, 1954; Machlis, 1953a, b) for the utilization of nitrogenous compounds, the generalization (Cantino, 1950) that chytrids which do not decompose cellulose do not readily utilize inorganic nitrogen is also rendered quite dubious, if not untenable.

Finally, Crasemann suggests a single evolutionary line, at the nutritional level, leading from the Chytridiales to the Blastocladiales. The writer is fundamentally in accord with this suggestion, but with certain reservations which are more logically

considered at the end of the following section on the Blastocladiales.

Blastocladiales. Further studies of the nutrition of five different species (including nine strains) of *Allomyces* (Ingraham and Emerson, 1954) have revealed that:

(A) not only is a reduced form of sulfur required for growth but, of the compounds tested, only methionine will suffice. Machlis (1953b), too, has shown that methionine cannot be replaced by sulfate, and Yaw and Cutter (1951) also found it necessary to incorporate methionine in the synthetic medium which they developed for the study of *Allomyces*. Thus, it seemed likely to Ingraham and Emerson that Quantz's unidentified cofactor (cf. Cantino, 1950) may well have been methionine. (B) In corroboration of Quantz's (1943) earlier reports, thiamine is, indeed, required for growth (cf. also Machlis, 1953a). Finally, (C) contrary to the implications which might be derived from the findings of Wolf and Shoup (1943; see discussion in Ingraham and Emerson, 1954), a limited number of carbohydrates did serve as satisfactory carbon sources for growth. The same conclusion derives from Machlis' (1953c) investigations of carbon nutrition. On the other hand, Quantz had concluded that a variety of sugars, far greater than that reported by Ingraham and Emerson, and by Machlis, yielded increased growth of *Allomyces* over that of controls without added carbohydrates. But, in view of the more primitive, less exacting, techniques used by Quantz for evaluating growth, it seems justified to accept the data of Ingraham and Emerson, and of Machlis, as the most reliable on the carbon nutrition of *Allomyces*.

Finally, prior to 1950, the question whether or not ammonium compounds could be used as sole sources of nitrogen for growth of *Allomyces* remained a moot point (Cantino, 1950). By more critical and selective manipulation of cultural conditions, Machlis (1953a, b) has now demonstrated that, indeed, *Allomyces* can so utilize ammonium-N. Concomitantly, it was also shown that nitrate cannot replace ammonium salts or organic nitrogen compounds.

New and more definitive nutritional data are now available for a second member of the Blastocladiales, *Blastocladiella*. Using a different species, Cantino (1951b) and Barner and Cantino (1952) have corroborated Quantz's conclusion that thiamine, or at least its pyrimidine moiety, is essential for growth. Furthermore, a reduced form of sulfur is required; either methionine or cystine serves as the sole source of sulfur for growth, whereas sulfate does not do so. In contrast to *Allomyces*, however, growth of *Blastocladiella* is not supported by ammonium compounds although an organic form of reduced nitrogen such as glutamate serves the purpose satisfactorily. It should be noted that in the foregoing studies, the incorporation of pH indicators in the cultures permitted continuous, visual estimation of the reaction of the medium throughout the incubation period; consequently, the absence of growth on media containing ammonium ions cannot be due to an unfavorable pH such as Machlis finds for *Allomyces*. For the moment, it must be accepted as a fact, therefore, that *Allomyces* can use ammonium compounds as sole sources of nitrogen for growth, but that at least one species of *Blastocladiella* (like *Blastocladia pringsheimii*, Cantino, 1950; however, see below) cannot do so.

Because no data are yet available on the nutrition of the Monoblepharidales, conclusions about synthetic capacities and phylogeny in the uniflagellate series must be based, once again, upon available knowledge of the two orders, Chytridiales and Blastocladiales.

In concluding her remarks, Crasemann (1954) suggested an evolutionary line descending from the Chytridiales to the Blastocladiales. This notion was apparently based upon the facts that: (a) the three well-established, saprophytic genera of the Blastocladiales require thiamine for growth; (b) these same fungi possess an absolute requirement for reduced sulfur; (c) *Allomyces* is now known to be able to utilize ammonium compounds as sole sources of nitrogen for growth; and (d) two species of *Blastocladia* (*B. ramosa* and *B. pringsheimii*) studied by Crasemann (see McEown, 1952) also grow in media containing ammonium compounds as sole sources of nitrogen. Her simplified version is a necessary consequence of most of the facts now available. But, certain strains of *Blastocladiella* and *Blastocladia* are clearly not capable of utilizing ammonium compounds as sole sources of nitrogen for growth under conditions where this inability simply cannot be ascribed to an adverse reaction of the medium. Therefore, whereas ammonium compounds do support the growth of several species of *Allomyces*, and of one strain each of *Blastocladia pringsheimii* and *Blastocladia ramosa*, they do not support the growth of *Blastocladiella emer-*

sonii and of a second strain of *Blastocladia prinsheimmii* (Cantino, 1950). Finally, while the thiamine requirements of *Macrochytrium* and *Chytridium* appear to be beyond dispute, the fact remains that other members of the Chytridiales are autotrophic for this same vitamin (Cantino, 1950).

So, employing a more simplified and conservative attitude than that used previously (Cantino, 1950), it may be deduced once again that from a nutritional point of view the Chytridiales complex includes the most primitive members of the uniflagellate series. Reduced to a simple but sound common denominator, the chytrids are fungi (a) all of which appear to have retained the primitive capacity to reduce highly oxidized forms of sulfur such as sulfate for growth; (b) some of which have retained the similarly primitive capacity to synthesize all essential vitamins while others have lost the capacity to synthesize one of them, thiamine; and finally, (c) some of which have retained the capacity to use both oxidized and reduced forms of inorganic nitrogenous compounds (e.g., nitrate and ammonium salts) for growth, while others have lost the capacity to utilize nitrate sources.

The Blastocladiales, whose nutritional characteristics are more advanced, appear to be fungi (a) all of which have lost the capacity to reduce sulfate and thus require a reduced organic form of sulfur for growth, and two of which, in fact, have specifically lost the capacity for synthesizing methionine; (b) all of which, without exception, have lost the capacity to synthesize the pyrimidine moiety of, if not the complete, thiamine molecule, and one of which has suffered an additional loss in capacity for synthesis of biotin and nicotinamide; and finally, (c) all of which have lost the capacity to reduce nitrate as the sole source of nitrogen for growth, while some have even lost the capacity to use ammonium compounds for this purpose.

With respect to their sulfur, vitamin, and nitrogen nutrition, the Blastocladiales are clearly more specialized and more dependent upon the environment than the Chytridiales. The latter represent the more primitive, and the former the more advanced, members of the uniflagellate aquatic Phycomycetes.

Saprolegniales. In her studies of nine species of the Saprolegniales, Reischer (1951a) has corroborated the notion (Cantino, 1950) that members of this order are generally incapable of utilizing sulfate as the sole source of sulfur for growth. Although some of her interpretations have been questioned (cf. Machlis, 1953a), it is nevertheless quite clear from her subsequent investigations (1951b) that these same fungi (in this case, eleven species tested) can assimilate ammonium salts as sole sources of nitrogen for growth. Whether or not ammonium-N could be so utilized had not been clearly ascertained previously (Cantino, 1950), but in the light of Reischer's work with a rather large number of different species and strains, it appears certain that the Saprolegniales, as a whole, have retained the capacity to grow on ammonium-nitrogen. Except for this modification, our current understanding of their synthetic capacities does not differ from that of 1950.

Leptomitales. During the past five years, no new light has been shed upon the nutrition of these interesting biflagellate Phycomycetes. The results obtained by Schade and Thimann (summarized in Cantino, 1950) have neither been affirmed nor denied and, for the moment, the case for the Leptomitales must continue to rest solely upon their work.

Peronosporales (*Pythiaceae*). It appears to be a standard procedure in many laboratories to adjust the pH of a batch of culture medium to a uniform value prior to autoclaving and inoculating with the test fungi, and then to determine the final reaction of the medium once again following cessation of growth. There is no question but that it is better to have some knowledge of the final pH than to have none at all, but pH control at some relatively constant value throughout growth will always be of infinitely greater utility.

In Mehrotra's recent studies (1950) of the growth of some ten species of *Phytophthora* on various sulfur compounds, pH control was at best ill-defined; the final pH of seven cultures had fallen to ca. 3, and that of two other cultures to ca. 4 and 5, respectively. Thus, the decrease in the reaction of the medium was an independent, uncontrolled variable which renders it impossible to arrive at definitive and really satisfactory conclusions regarding the utilization of sulfur compounds. The fact that some species of *Phytophthora* grew vigorously in certain culture media witha final pH of ca. 3, and that they did not do so on other media with a comparable final pH, does not necessarily rule out the possibility that such a low pH, per se, was responsible for the observed lack of

growth. These facts, combined with other anomalous results (e.g., the comparative effects of cysteine vs. cystine on growth), make it difficult to derive completely meaningful conclusions from Mehrotra's study. However, judging mainly from the *positive* data available, it can be concluded with reasonable certainty that many of his strains of *Phytophthora* do utilize organic and inorganic sulfur compounds including sulfate, at various levels of oxidation, as sole sources of sulfur for growth.

Similarly, Saksena, Jain, and Jafri (1952) concluded that seven species of *Pythium* also utilize a large variety of inorganic sulfur compounds, including sulfate, as well as organic compounds such as cysteine and cystine.

Finally, one species of *Pythiogeton* (Cantino, 1951a), like the genera *Pythium* and *Phytophthora* also grows vigorously in media wherein the sole sulfur source may be one of a large variety of compounds containing sulfur at different levels of oxidation, again including sulfate.

With regard to nitrogen nutrition, ammonium compounds as well as some amino acids generally serve adequately as sole sources of nitrogen for some thirteen species of *Pythium* (Saksena et al., 1952). *Pythiogeton* also utilizes ammonium compounds as sole sources of nitrogen for growth (Cantino, 1951a). Of twenty-five amino acids tested, four of them also supported vigorous growth when substituted for ammonium-N. In contrast, French (1953) and Saksena and Bhargava (1943) have suggested that certain species of *Phytophthora* (e.g., *P. infestans* and *P. phaseoli*) are inhibited to some degree by ammonium-nitrogen in media which otherwise support vigorous growth. Perhaps, however, ammonium salts might well have served as nitrogen sources if different environmental conditions had been employed wherein rigid control of the reaction of the medium could be maintained. (Cf., for example, the discussion in Machlis, 1953a, Foster, 1949, and investigations of other, non-aquatic fungi; e.g., those of Tanaka, Katsuki, and Katsuki (1952) on the rice blast fungus, wherein ammonium compounds, originally reported as unfavorable nitrogen sources for growth, did indeed serve the purpose admirably when the changes in reaction of culture media resulting from selective absorption of ammonium ions were prevented by adequate buffering or other suitable pH control.)

Knowledge of the vitamin nutrition of the Pythiaceae has been extended by the reports of Saksena et al. (1952; see also, Saksena and Bhargava, 1943) and Rossetti, Bitancourt, and Kucaynska (1952). In keeping with the results of almost all studies reported previously (Cantino, 1950), the *Pythium* and *Phytophthora* species studied herein are heterotrophic for thiamine.

Finally, with respect to carbon nutrition, Mehrotra's (1951) investigation of ten species of *Phytophthora* suggests that various sugar alcohols, sugars, and other carbohydrates serve more or less adequately as sole sources of carbon for growth. Once again, however, Mehrotra's negative results are difficult to evaluate because of the variability of the pH changes which occurred in the culture media during growth. Saksena and Mehrotra (1949) arrived at the generally similar conclusion that quite a few carbohydrates support the growth of several species of *Pythium*. And yet, in an extensive and thorough survey of the utilization of sugars by fungi, Lilly and Barnett (1953) report that whereas *Phytophthora infestans* grows well on media containing either glucose or fructose, most other sugars support little or no growth.

As a general rule, the variety of compounds which serve as sole sources of carbon for the growth of fungi is far greater than that of compounds capable of serving as sources of nitrogen and sulfur, respectively, and that of vitamins known to be required for growth. Thus, data on the nitrogen, sulfur, and vitamin nutrition of the water molds ought to be of far greater utility than those on carbon nutrition for ascertaining phylogenetic relationships. Besides, Lilly and Barnett call attention to the problem of interpreting the results of experiments wherein the rates of growth of different fungi vary widely with the age of the cultures. They rightly insist, furthermore, that insufficient attention has been given to the behavior of fungi under those conditions where some sugars are utilized slowly, only in part, or not at all, when they are supplied singly, but where these same sugars are nevertheless used rapidly (or support rapid growth) when a second readily utilizable sugar is also present. For these and other reasons, the nutritional relationships among the members of the biflagellate (and also the uniflagellate) series are reconsidered, for the time being, solely on the basis of nitrogen, sulfur, and vitamin nutrition.

Today, the status of the synthetic capacities of the biflagellate, aquatic Phycomycetes appears to

be substantially the same as it was in 1950; the additional evidence now available has slightly modified, strengthened, and in the main corroborated the original point of view. The Saprolegniales have lost the ability to utilize sulfate and nitrate as sole sources of sulfur and nitrogen, respectively, for growth. On the other hand, practically all species have retained the capacity (a) to assimilate and use ammonium-nitrogen as the sole source of this element for growth, and (b) to synthesize all essential vitamins.

In the absence of further evidence, it can only be generalized once again that the Leptomitales, in contrast to the Saprolegniales, (a) have lost the ability to utilize both ammonium and nitrate compounds as sole sources of nitrogen for growth, but (b) have retained the capacity to reduce and utilize sulfate for the biosynthesis of all essential, sulfur-containing cell constituents. Like the Saprolegniales, however, they have remained autotrophic for all essential vitamins.

The aquatic Peronosporales, like the Leptomitales, have retained the capacity to satisfy all essential sulfur requirements with sulfate. Like the Saprolegniales, on the other hand, practically all of them have retained the ability to use ammonium-N to satisfy growth requirements. But, unlike either the Saprolegniales or the Leptomitales, they have become partially or completely heterotrophic for thiamine or its pyrimidine constituent. Once again, therefore (and placing the main emphasis on sulfur nutrition as was done previously; Cantino, 1950), it seems most logical to assume one evolutionary trend leading to the Saprolegniales, and a second one leading, via an early dichotomy, to the Peronosporales and Leptomitales (see Fig. 1).

CELLULAR METABOLISM AND BIOCHEMISTRY

Chytridiales. The literature on aquatic Phycomycetes is almost barren of reports of fundamental aspects of either the cellular metabolism or biochemistry of the chytrids. A few isolated facts which have some bearing upon the following discussion can be found in three recent publications.

Karlingia (*Rhizophylyctis*) *rosea* is incapable of growing under an atmosphere of tank nitrogen (Haskins and Weston, 1950). Presumably, the oxygen tension under such conditions of continuous "nitrogenation" must have been maintained at a level roughly equivalent to one mm. of Hg or less. The fungus is said to be able to survive, however (without significant proliferation), under micro-aerophilic conditions for about three weeks.

The orange pigment in a different strain of *Rhizophlyctis* (*Karlingia?*) *rosea* is due almost wholly to the presence of gamma carotene (Cantino and Hyatt, 1953b). Cell-free preparations of the chytrid display cytochrome oxidase and succinic dehydrogenase, but virtually no alpha-ketoglutarate oxidase activity.

Among the non-pigmented species of Chytridiales, *Macrochytrium* not only tolerates but grows vigorously under a degree of anaerobiosis which, judging from Crasemann's (1954) experimental procedure, must have been at least equivalent to if not greater than that used for the *Karlingia* (*Rhizophylctis*) studied by Haskins and Weston. Significantly, *Macrochytrium* is also a vigorous producer of acidic metabolic products, almost all of the acidity being due to lactic acid. *Chytridium* can not grow under similar, anaerobic conditions (Crasemann, 1954), but it, too, produces lactic acid during growth.

Blastocladiales. Of the three, well-established, saprophytic genera of the Blastocladiales, *Blastocladiella* appears to be more closely allied to the monocentric chytrids in its superficial, gross, structural details than it does to either *Blastocladia* or *Allomyces*.

Sparrow's (1950) recently-described *Blastocladiopsis* is no exception to this generalization. However, some purportedly-new genera and species (Sörgel, 1952), if established as valid, also appear to be more chytridiaceous and less blastocladiaceous in general appearance than either *Blastocladia* or *Allomyces*.

Cantino and Hyatt (1953a, b, c) have investigated (1) two wild type species of *Blastocladiella*, *B. emersonii* and *B.* (*simplex?*), similar to one another in all essential respects but distinguishable on certain morphological grounds, and (2) two orange-colored, mutant strains of *Blastocladiella* derived therefrom. Both mutant strains, clearly of blastocladiaceous origin, produce large quantities of gamma carotene, as do *Rhizophlyctis* (see above) and *Allomyces* (Emerson and Fox, 1940). Biosynthesis of carotene is stimulated by cycloheximide, as it is in *Allomyces* (Whiffen, 1951), but whether or not diphenylamine also affects the biosynthetic mechanism (cf. Turian, 1952) is not known. Cell-free preparations derived from both mutant strains of *Blastocladiella* possess quite comparable cytochrome oxidase and succinic dehydrogenase activ-

ities but lack demonstrable ketoglutarate oxidase activity (as is also true for *Rhizophlyctis*).

The wild type *Blastocladiella emersonii* has been investigated intensively since 1950 (Brown, 1954; Brown and Cantino, 1955; Cantino, 1951b, 1952, 1953; Cantino and Horenstein, 1955; Cantino and Hyatt, 1953a, b, c). The orange (male?) plants of this fungus are also believed to contain gamma carotene. Like Crasemann's chytrids, particularly *Macrochytrium*, it produces acid vigorously during growth; in fact, lactic acid is practically the sole, acidic, metabolic product formed. Both indirect evidence, derived from in vivo studies of growing organisms, and direct evidence, derived from in vitro studies of cell-free preparations, provide a reasonably solid basis for the existence, in this fungus, of a terminal cytochrome oxidase, an atypical "polyphenol oxidase", and most of the enzymatic activities associated with the reactions of the tricarboxylic acid cycle. And yet, the data on lactate production during growth are strongly suggestive of a fermentative mechanism wherein glucose is converted stoichiometrically, presumably via pyruvate, to two molecules of lactate. Besides, Brown and Cantino (1955) and Cantino and Hyatt (1953c) have shown (a), that metabolism of glucose by preformed cell suspensions and cell free homogenates of *B. emersonii* is not associated with a concomitant increase in oxygen consumption above the endogenous levels obtained in the absence of added substrate, and (b), that malate is rapidly converted by cell-free preparations to lactate, some oxaloacetate, and other as yet unidentified products of the reaction; simultaneously, pyruvate (a presumed intermediate) accumulates only in trace quantities and thus appears to turn over rapidly. Therefore, whether the substrate be a C_6 skeleton such as glucose, or a C_4 or C_5 skeleton normally found in the tricarboxylic acid cycle rather than on the glycolytic pathway, it is converted either stoichiometrically or in large measure to the same C_3 end product, lactate. Incorporation of a few cofactors and other compounds suspected of being possible limiting factor in the initiation of C_6 synthesis via C_4 plus C_2 condensation did not significantly modify this general trend in metabolism (Brown, 1954).

Thus, irrespective of the pathway leading to pyruvate in proliferating cells, pre-formed and non-proliferating cell suspensions, or cell-free preparations, whether it be via glycolysis (or monophosphate shunt?) or via intermediates of the tricarboxylic acid cycle, *Blastocladiella* certainly appears to possess a weak C_2-forming mechanism and, concomitantly, a strong tendency for production of lactate.

Finally, both in vivo and in vitro studies have provided extensive and generally-consistent evidence that one phase of morphogenesis in *Blastocladiella* is initiated and maintained specifically by bicarbonate, which appears to interfere with a biotin-dependent oxidation of ketoglutarate in the tricarboxylic acid cycle.

The pyruvate-decarboxylation mechanism associated with a loss in capacity for biosynthesis of thiamine in *B. emersonii* is, at best, a poorly developed one and a rate-limiting step in the initiation and maintenance of a weakly functional tricarboxylic acid cycle. As a *direct source of energy for growth*, the latter probably contributes very little to the overall metabolic machine. Nevertheless, judging from comparative biochemistry, it seems an inescapable conclusion that it must play many essential roles, directly and indirectly. One such vital function has been partially elucidated; it appears to deal with the morphogenetic mechanism leading to the formation of resistant sporangia.

It is significant that *Blastocladiella* can not grow in the absence of thiamine, but that it can grow if thiamine is replaced by a mixture of pantothenate, bicarbonate, and acetate. This observation is consistent with the notion that *Blastocladiella* possesses a weak C_2-forming mechanism. More important, however is the fact that (1) judging again from comparative biochemistry, thiamine might also be expected to be required for the oxidation of ketoglutarate, and (2) that, in this second role, it ought not to be replaceable by a mixture of pantothenate, bicarbonate, and acetate if the tricarboxylic acid cycle provided a substantial portion of the energy needed for growth. The fact that growth does, indeed, occur when this substitution is made is again in keeping with the above suggestions regarding the role of the tricarboxylic acid cycle in *B. emersonii*.

A second genus, *Blastocladia*, which is heterotrophic for thiamine, is also a vigorous lactate producer (Emerson and Cantino, 1948; Cantino, 1949). In fact, during the major portion of glucose dissimilation, when rates are linear, preformed suspensions carry on an essentially homolactic fermentation. Only when rates finally taper off toward the end of the fermentation does a discrepancy arise due to the production of some succinic acid. Furthermore, *Blastocladia* not only tolerates, but

grows actively under, an oxygen tension equivalent to less than a mm. of Hg; under these conditions, the detectable products of glucose metabolism are qualitatively the same as those produced under strongly aerobic conditions. It is a reasonable assumption that *Blastocladia*, too, possesses a poorly developed C_3-forming mechanism (cf. also Foster, 1949); fermentable carbohydrates, essential for growth, are apparently carried to pyruvate and there reduced almost stoichiometrically to lactate.

In *Blastocladia*, too, as in *Blastocladiella*, one phase of morphogenesis (production of resistant sporangia) is also under the control of the same specific factor, bicarbonate. On the basis of (a) analogy with our more detailed knowledge of the function of the bicarbonate trigger mechanism in *Blastocladiella*, (b) the lack of detactable CO_2 production during growth on, or dissimilation without growth of, glucose, and (c) the effect of added CO_2 upon the products of metabolism whereby production of succinate is increased and that of lactate decreased, it is reasonable to assume that one or more sites of CO_2 fixation must also exist in the metabolic machinery of *Blastocladia*. Indeed, Lynch and Calvin (1952), using labeled substrate, have demonstrated that dark fixation of CO_2 does occur in *Blastocladia pringsheimii*; significant quantities of the tracer appear in polysaccharides, amino acids such as aspartate, and intermediates of the tricarboxylic acid cycle such as malate, succinate, and fumarate.

Finally, although *Blastocladia* grows actively under inordinately low oxygen tensions, it is noteworthy that such concentrations of oxygen are nevertheless absolutely required for growth. All of these facts, then, make it highly probable that in *Blastocladia*, as in *Blastocladiella*, (a) the energy required for growth is in the main derived from fermentative mechanisms, and that (b) the tricarboxylic acid cycle, if functional, serves in other capacities, one of which may also be concerned with the morphogenetic mechanism leading to the formation of resistant sporangia.

The third member of the Blastocladiales, *Allomyces*, also converts glucose into large quantities of lactic acid during growth, roughly one third of the carbon being recovered as lactate, one third as carbon dioxide, and one third as mycelial carbon, plus traces of acetaldehyde (Ingraham and Emerson, 1954). But, under anaerobic conditions, preformed suspensions of *Allomcyes*, like *Blastocladiella* and *Blastocladia*, carry on an essentially homolactic fermentation, ca. 90 per cent of the glucose carbon being recovered as lactic acid.

With respect to oxidative metabolism, Leonard (1949) reports that a variety of tricarboxylic acid cycle intermediates (fumarate, malate, cis-aconitate, ketoglutarate, succinate) stimulate oxygen consumption in *Allomyces* above the endogenous levels obtained in the absence of added substrate. Because of the techniques used for the preparation of mycelial suspensions, Leonard's interpretations are open to question (cf. for example, discussion in Ingraham and Emerson, 1954, of the work of Wolf and Shoup). Also, increases in oxygen consumption were often low enough to be of dubious significance (e.g. 10 to 40 per cent increases above the endogenous). These results may not be sufficiently definitive, therefore, to offer suggestive evidence for the existence of a tricarboxylic acid cycle in *Allomyces*. Shoup and Wolf (1946) suggest that starved mycelia of four species of *Allomyces* possess a cyanide sensitive terminal oxidase system (10^{-2} M cyanide yielded 80–93 per cent inhibition), but their conclusions must be viewed with the same degree of caution because of the preparatory procedures employed.

Finally, Lynch and Calvin (1952) have discovered that *Allocyces* also fixes CO_2 into polysaccharides, aspartate and glutamate, and to a lesser extent succinate and fumarate. However, although CO_2 and bicarbonate play a vital role in morphogenesis in *Blastocladiella* and *Blastocladia*, no attempts have been made to discover if they might play a similar role in *Allomyces* (see Jones, 1946, for studies of the effect of other environmental factors on formation of resistant sporangia).

How, then, does the physiology of *Allomyces* compare with that of its relatives among the Blastocladiales? In commenting upon their studies, Ingraham and Emerson suggest that although both *Allomyces* and *Blastocladia* produce lactic acid, they are otherwise dissimilar in that (a) *Blastocladia* is a facultative anaerobe which produces lactate and succinate but not CO_2, and whose qualitative metabolism is not altered by aerobic vs. anaerobic conditions, whereas (b) *Allomyces* is a strict aerobe which produces lactic acid and CO_2 aerobically but which carries on a homolactic fermentation anaerobically (*Blastocladiella* was not included in the comparison). The writer prefers the following interpretation: (a) the difference in capacity to grow "anaerobically" is one of degree, not of kind; *Blastocladia* will not grow under

strictly anaerobic conditions where the oxygen tension is lower than ca. one mm. of Hg, and where methylene blue is reduced to its leuco form; (b) the observed difference in CO_2 production is also probably one of degree. *Blastocladia* produces no *detectable* CO_2 during growth or dissimilation, but, it seems quite necessary to assume, in view of the observed redox balance (Cantino, 1949), that some must be produced and that it is then rapidly reassimilated and fixed into cell constituents.

With the preceding discussion about *Blastocladiella* and *Blastocladia* in mind, the writer therefore concludes that all three genera in the Blastocladiales display a fundamentally similar type of metabolism (Fig. 1).

Monoblepharidales. One species, *M. taylori*, is mentioned briefly by Shoup and Wolf (1946); they report that it, like *Allomyces*, appears to have a CN-sensitive terminal oxidase system. But in light of the objections already raised regarding the starvation methods employed, and because it is not clear whether or not pure cultures of *M. taylori* were used, it must be concluded, once again, that practically nothing is known about the cellular physiology of this interesting group of aquatic Phycomycetes.

In summary, then, it appears that in the uniflagellate series the following points are applicable: (1) in all instances where analyses for metabolic products have been made following metabolism of carbohydrate during growth or dissimilation of carbohydrate by preformed cell suspensions and cell-free preparations, most of the substrate carbon liberated has been recovered as lactic acid. Indeed, all three genera of the Blastocladiales can carry on an almost pure homolactic fermentation. Furthermore, representatives of both the Chytridiales and the Blastocladiales grow vigorously under extremely low levels of oxygen tension, levels, in fact, which do not support the growth of filamentous fungi from any other order of the Eumycophyta. Thus, the uniflagellate series appears to be characterized by a fermentative rather than an oxidative type of metabolism.

(2) Conversely, all available evidence is not only consistent with, but strongly suggestive of, the existence of a tricarboxylic acid cycle in at least some members of the Blastocladiales. The cycle, however, appears to be a weakly functional system whose origin and maintenance is limited by a feeble or deranged C_2-forming mechanism. Its utility, therefore, does not relate primarily to energy production in the metabolic machinery of the growing organism but, rather, to other essential roles. For *Blastocladiella*, and perhaps for *Blastocladia*, one such vital role is probably the initiation and maintenance of one phase of morphogenesis.

Saprolegniales. In contrast to the uniflagellate fungi, many saprophytic, biflagellate Phycomycetes have been cultured for decades with relative ease. But, because most of the physiological investigations have dealt with nutrition, knowledge of their cellular metabolism and biochemistry remains extremely meagre. For our purpose, therefore, perhaps the most significant insight into their metabolism is to be derived from certain, rather superficial observations made by students of the water molds; namely, that in contrast to the Chytridiales and Blastocladiales, the Saprolegniales apparently do not generally produce appreciable, or even detectable, quantities of acidic metabolic products (cf. Reischer, 1951b). If reasonably large quantities of organic acids were liberated during growth, either inordinately concentrated buffers, or an extremely vigorous differential absorption of anions by a fungus, would be required to nullify the resultant pH drop. Therefore, in spite of the lack of actual analytical data for the organic acid content of spent culture media, it is a fairly reliable assumption that the Saprolegniales produce little if any acid during growth on the synthetic or complex culture media usually employed. Reischer also observed that most Saprolegniales (eleven species studied) grew well in media wherein ammonium compounds were supplied as the sole sources of nitrogen provided that tricarboxylic acid cycle intermediates such as malate and succinate were present; she suggested that such intermediates functioned as substitutes for CO_2 in the maintenance of a Krebs cycle in these fungi. It is true that some of her conclusions were questioned (Machlis, 1953a), e.g., how to explain her observations that at certain pH values, the acids are not required. But she also reported that these and some other di- and tricarboxylic acids yield increased values for oxygen consumption over the endogenous levels.

On the whole, the facts available are at least consistent with the notion that the Saprolegniales, unlike the vigorously acid producing uniflagellate Phycomycetes, carry on an essentially oxidative rather than fermentative type of metabolism.

Leptomitales. Schade and Thimann (1940) have

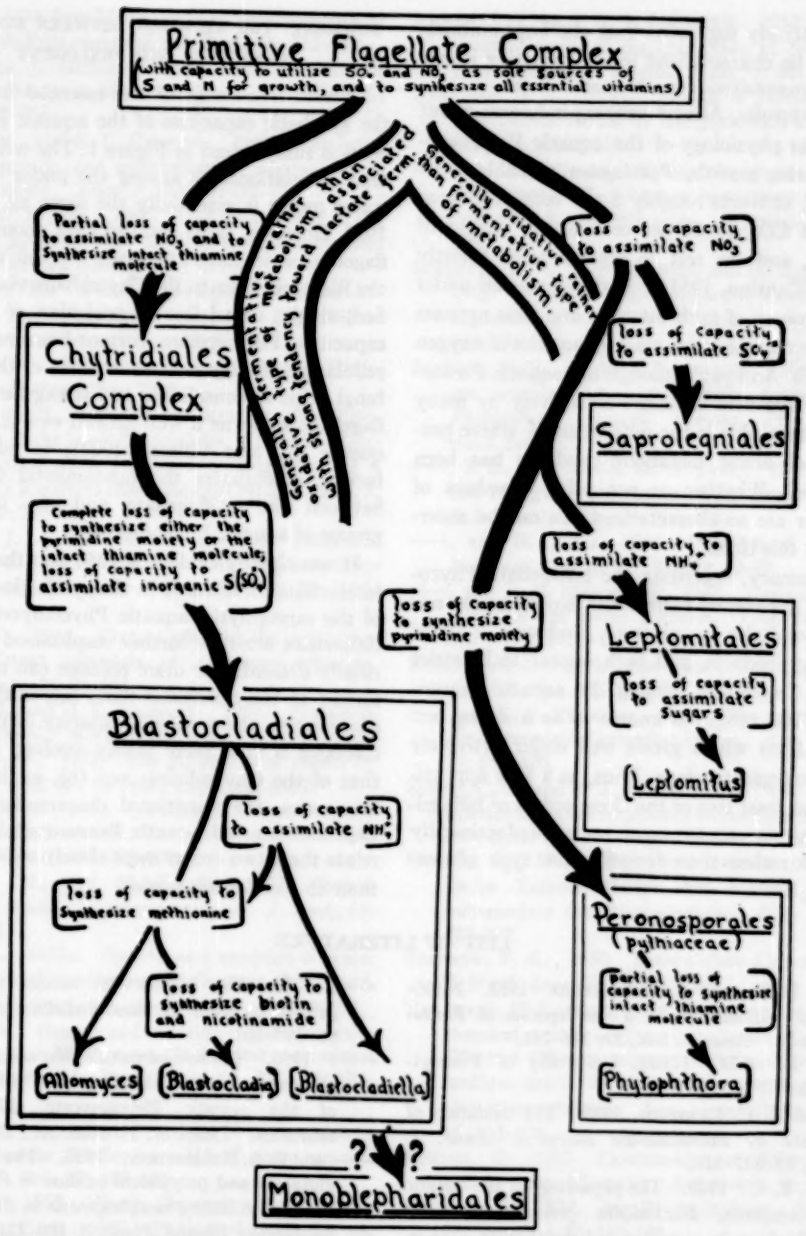
Primitive Flagellate Complex
(With capacity to utilize SO_4 and NO_3 as sole sources of S and N for growth, and to synthesize all essential vitamins)
Partial loss of capacity to assimilate NO_3 and to synthesize intact thiamine molecule
Chytridiales Complex
Generally fermentative rather than oxidative type of metabolism associated with strong tendency toward lactate ferm.
Generally oxidative rather than fermentative type of metabolism.
loss of capacity to assimilate NO_3
loss of capacity to assimilate SO_4
Saprolegniales
Complete loss of capacity to synthesize either the pyrimidine moiety or the intact thiamine molecule; loss of capacity to assimilate inorganic S(SO_4)
loss of capacity to assimilate NH_4
loss of capacity to synthesize pyrimidine moiety
Leptomitales
loss of capacity to assimilate sugars
Leptomitus
Blastocladiales
loss of capacity to assimilate NH_4
loss of capacity to synthesize methionine
loss of capacity to synthesize biotin and nicotinamide
Allomyces
Blastocladia
Blastocladiella
Peronosporales (pythiaceae)
partial loss of capacity to synthesize intact thiamine molecule
Phytophthora
?
?
Monoblepharidales

FIG. 1. PHYLOGENETIC RELATIONSHIPS AMONG THE WATER MOLDS, BASED UPON THEIR SYNTHETIC CAPACITIES

(The term "loss in capacity" is again restricted in meaning. For example, "loss of capacity to assimilate sulfate . . ." implies that this substance, when used as the *sole source* of sulfur, will not support growth).

clearly demonstrated that *Leptomitus* is a strict aerobe which (a) oxidatively deaminates certain amino acids, (b) oxidizes various fatty acids to carbon dioxide and water but cannot respire sugars, and (c) carries on a very efficient oxidative assimilation. There is no denying the inherent weakness of any generalization based upon a single investigation. As a working hypothesis, however,

it is tentatively suggested that the Leptomitales, too, may be characterized by an oxidative rather than a fermentative type of metabolism.

Peronosporales. Almost nothing is known about the cellular physiology of the aquatic Peronosporales. During growth, *Pythiogeton*, a cellulose decomposer, converts roughly 3 per cent of glucose carbon to CO_2, 15–20 per cent to dry weight of organism, and the rest to organic acids (mostly lactate) (Cantino, 1951a). It develops well under an atmosphere of tank nitrogen and thus appears to require no more than trace quantities of oxygen for growth. And yet, although the aquatic *Peronosporales* have been cultured extensively by many investigators, this is the only instance where production of acidic metabolic products has been established. Whether or not other members of this order are so characterized can not be ascertained at this time.

In summary, regarding the biflagellate Phycomycetes: apparently neither the Saprolegniales nor the Leptomitales are vigorous producers of acidic metabolic products, and both appear to be strict aerobes. Conversely, among the aquatic Peronosporales, one fungus is known to be a strong lactate producer which grows well under extremely reduced oxygen tensions. Thus, as a first approximation, at least two of the three orders of biflagellate fungi appear to carry on a predominantly oxidative rather than fermentative type of metabolism.

SUMMARY: THE RELATION BETWEEN SYNTHETIC CAPACITIES AND PHYLOGENY

Current knowledge of the essential features of the synthetic capacities of the aquatic Phycomycetes is summarized in Figure 1. The writer's concept of relationships among the major groups of water molds is essentially the same as it was in 1950. However, more detailed data about the uniflagellate series have now made it possible to relate the Blastocladiales to the Chytridiales via a simplified, single, broad line of evolution of synthetic capacities. Furthermore, current knowledge of the cellular physiology and metabolism of the aquatic fungi helps to consolidate and strengthen the uniflagellate series as a well-defined evolutionary sequence (cf. also Villeret, 1952); in addition, it further accentuates the fundamental differences between the uniflagellate and the biflagellate groups of aquatic Phycomycetes.

It was already evident in 1950 that there existed interordinal differences in the synthetic capacities of the saprophytic, aquatic Phycomycetes. These differences are now further emphasized and more clearly defined. Far more reliance can now be attached to the conclusion that: (a), in the uniflagellate series, the synthetic capacity of the Blastocladiales is at a more highly evolved level than that of the Chytridiales; and (b), in the biflagellate series, the nutritional characteristics of the Leptomitales and aquatic Peronosporales tend to relate these two orders more closely to one another than to the Saprolegniales.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

REVIEWS AND BRIEF NOTICES

General Biology: Philosophy and Education..... 150
Biology: History and Biography..... 153
The Young Naturalist..... 155
Ecology and Natural History..... 156
Evolution..... 162
Genetics and Cytology..... 165
General and Systematic Botany..... 167
Plant Morphology..... 172
Plant Physiology..... 172
Economic Botany..... 174
General and Systematic Zoology..... 179
Economic Zoology..... 185
Animal Growth and Development..... 187
Animal Morphology..... 189
Animal Physiology..... 189
Biophysics and General Physiology..... 192
Biochemistry..... 193
Microbiology..... 194
Health and Disease..... 196
Psychology and Animal Behavior..... 198
Human Biology..... 202
De Omnibus Rebus et Quibusdam Aliis..... 205

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

BIOLOGY. *Second Edition.*

By Claude A. Villee. W. B. Saunders Company, Philadelphia and London. $6.50. xx + 670 pp.; ill. 1954.

"In any elementary text it is sometimes difficult to steer a course between the Scylla of superficiality and the Charybdis of overdetail. Since I believe superficiality to be the greater danger, I have tried to present, without overloading the students with facts, the information he should acquire in a college course in biology." This statement in Villee's Preface gives one a clue to what can be expected throughout his textbook. He has masterfully managed the great complex mass of knowledge that is modern biological science, and his avoidance of superficiality has set standards which are seldom achieved.

Not only is superficiality avoided, but the sequence and balance of subjects can hardly be bettered. A chapter on science in general is followed by chapters on protoplasm, cells, and tissues. A chapter on cellular metabolism precedes, and a chapter on green plant cells follows one chapter on ecology which includes, among others, discussions of nutrition, cycles, and interactions between species. Five more chapters are devoted to plants. A general discussion of animals occupies the next 3 chapters, while the next 13 are essentially human anatomy and physiology. Reproduction, embryology, and heredity are then discussed against the broad background of the first 26 chapters. Evolution follows in 4 chapters and these are followed by a second chapter on ecology. The final chapter deals with those aspects of ecology and evolution that are intimately a part of both areas. The appendix consists of synopses of the plant and animal kingdoms. There is an excellent bibliography of about 180 titles.

The placement of ecological subjects and of human physiology and anatomy is good in the above sequence. Since ecology is not a unified body of knowledge, the positions given to the ecological subjects are especially good because they neglect traditional organization and make clear solid bonds wrought by multiple connections to "outside" subjects. Human physiology and anatomy follow discussions of plants and lower animals and thus a more logical and economical sequence is achieved than if these subjects are placed first, as is often done.

In considering superficiality one must ask the questions: Is a direct consideration of the theoretical structure of a body of knowledge superficial to that body of knowledge? Is an examination of the general character-

istics of scientific theories purely philosophy or is it so intimately a part of science that a degree of superficiality cannot be avoided in its absence?

The only ways the general aspects of this book might have been bettered are in relation to the above questions. To me it seems that it would help the student to have an early chapter on the major theoretical concepts in biology, with a brief discussion of their general characteristics. This might have been done following the discussion of the cell, and thus the cell theory could have been used as a concrete example. The past changes undergone by the cell theory and the limits of its application are simple enough to present to elementary students in order to illustrate some characteristics of biological theories; and the present drift toward a biochemical cell theory (the energid concept of Sachs?) is most interesting.

A brief statement of the theory of evolution, as a part of the above suggested chapter, would be of great service to many discussions that occur before evolution is treated in full at the end of the book (e.g., pp. 57, 60, 107, 169, 218, 233, 293). Also the concept of biogenesis has been too important in the development of biology to be treated so obliquely (pp. 11, 12, 550). It is, however, good to find an author of an elementary textbook who will discuss Oparin's ideas on the origin of life (but is not "coazervate" the critical feature here?) and Horowitz's concept of the evolution of biochemical syntheses.

This author has, it seems, grasped the essence of sound science and sound pedagogy in the presentation of most of his subjects. Rather than attempt to deal with whole organisms, which at present is far too much for us to manage in our state of ignorance, he deals with whole concepts. And since it is concepts that create order among facts, this probably accounts for the clarity and efficiency of presentation throughout the book.

Some teachers may say that the book is too detailed and too difficult, and this may be so for a course that has only 4 or 5 class hours a week. But since this book is so well organized around concepts, the teacher who understands the concepts will have no trouble in making omissions here and there. Certainly it will be a great advantage to better students to have a non-superficial treatment of biology in their hands.

The discussion of enzymes is especially good and up to date. The discussions of cellular respiration and photosynthesis are excellent brief presentations of the more modern views on these subjects. Human anatomy and physiology are well integrated in the presentation of the concepts in physiology. Embryology is discussed in some detail. In genetics the author moves rapidly through the monohybrid and dihybrid crosses so that he can dwell on the phases of genetics that are, so to speak, closer to nature. Geographic distribution and adaptation are especially well presented in relation to evolution. With very few exceptions the illustrations are well chosen and well executed.

The discussion on scientific method (pp. 3 and 4) is difficult to evaluate. If the author means that a person formally trained in an area of knowledge should conduct a whole series of observations and experiments of his own before formulating any hypotheses, he is not giving sound advice. The analogy with the detective is not too good, either, because a detective has no facts about his case from which to theorize, but the scientist has many facts and concepts in his mind or at his command in the scientific literature. More often than not these are a sound basis for hypothesizing. Darwin has said in relation to the search for facts: "How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service."

Despite this possible difference of opinion, and the one or two noted earlier, one must say that this is a very exceptional book. The student who masters its content and catches its spirit will be well on his way to a superior grasp of biology.

RALPH W. LEWIS

BIOLOGY.

By Paul B. Weisz. McGraw-Hill Book Company, New York, Toronto, and London. $6.50. xviii + 679 pp.; ill. 1954.

The teacher who is looking for an original approach to the presentation of general biology will find one in this textbook, which is unique both in concept and execution. But if the potentialities of this approach are to be realized, the quality of both the student and the instructor should be considerably above average.

Weisz organizes his book under four general headings: environment, living substance, metabolism, and self-perpetuation. He does not attempt to treat each of these areas exhaustively in turn, but instead approaches these aspects of living systems on three separate and successive levels, with each level embodying a higher order of understanding and greater attention to detail. At the start he briefly, although not superficially, approaches a living system from a theoretical standpoint, indicating the kinds of problems which must be solved by such a system. On the second level he sketches the broad outlines of each aspect of the system, introduces essential terminology, and establishes a number of basic relationships. The third level of consideration comprises more than four-fifths of the book, and further develops the main concepts, culminating in a detailed study of genetics and evolution. While the same general ground is traversed three times, in practice there is very little repetition of material.

The author tells the student to enjoy the book, and does what he can to make this possible. The intellectual regimen is tempered by an informal narrative style which makes frequent use of simile, analogy, and common experience. The illustrations are adequate, the drawings being especially commendable for the lucidity

resulting from their remarkable simplicity. It is encouraging to see an emphasis throughout on the chemical bases of the living system; this material is presented in an attractive way that makes its mastery as nearly painless as possible.

Appearing perhaps for the first time in an introductory biology textbook, Weisz introduces the concept of steady-state control very early, and it serves an important integrative function throughout the book. An outline of plant and animal classification is given in an appendix, the taxonomic structure of the biotic world otherwise receiving little attention. The collateral readings suggested at the close of each chapter are well-chosen, and include works to challenge the exceptional student. This textbook, at present alone in its class, may well point the way for those yet to come.

FRANK C. ERK

INTRODUCTORY BIOLOGY. *Second Edition.*
Edited by Andrew Stauffer. D. Van Nostrand Company, Toronto, New York, and London. $6.50. xviii + 802 pp.; ill. 1954.

Do biological theories serve the same general purposes in biology as do theories in physics and chemistry? Do biologists know the difference between simple fact-finding and fundamental research? Do biologists agree with the following quotation from Einstein and Infeld (page 55), "In the whole history of science from Greek philosophy to modern physics there have been constant attempts to reduce the apparent complexity of natural phenomena to some simple fundamental ideas and relations. *This is the underlying principle of all natural philosophy.*"? (Ital. by R.L.) Do biologists think of theories as concepts which explain "various large and independent classes of facts" and not as generalizations by "simple enumeration?"

Questions such as these might well come into the reader's mind after completing the first chapter of this book. An outline of the characteristics of living things, a few facts about the chemical and physical structure of protoplasm, a two-page discussion of cells, and a paragraph on higher levels of organization—are these the Basic Biological Concepts? In this book they are so named. How, then, does one speak of the theory of evolution, the theory of biogenesis, the gene theory, and the cell theory? Are not these four theories the real basic concepts of biology? To the mind of this reviewer they are. And the reasons for considering them thus reside in our knowledge of the history of their development and in our understanding of the classes of facts subsumed by each concept, plus some understanding of the limits of application of each concept.

One can make sound arguments in favor of sexual reproduction and of growth as basic concepts. Sexual reproduction, however, is largely subsidiary to the above four theories, therefore it is not as "basic" as the four. Growth is also somewhat subsidiary, but it is difficult to judge its position as a unified concept possessing the attributes of good theory because it is just beginning to develop in this way. As a consequence, growth must be given a less "basic" position than the above four theories. Growth considered only as a generalization by simple enumeration should not even be placed among the basic concepts.

Respiration, considered here as the metabolic activity, is truly a basic concept. It has brought under one point of view several classes of facts which at one time were unrelated in the sense that they could not be explained on a common ground. It is a concept which is growing and is interrelating more and more facts. It has made possible the prediction of new facts and has suggested new relations. Since these are properties of successful theories, and since the concept is broad in its coverage, respiration is a basic concept.

If for a moment one goes beyond the consideration of an elementary textbook and asks the questions, Is the concept of respiration a part of the cell theory? Or is this a question that cannot reasonably be put today?, answers to both questions will depend upon how one views the modern cell theory. Has it reached its ultimate development or is it still a growing concept? Certainly, as presented in elementary textbooks of biology, botany, and zoology, the cell theory is a completed fact. Should it be considered as such so that eventually it will be subsumed under a broader concept, or is the cell theory today growing as it has in the past so that it may subsume respiration and all of metabolism?

Aside from the first chapter, which is unit one, there are nine categories, into which the remaining seventy-five chapters are grouped. The units deal with methods of securing food, transport, utilization of foods and excretion, coordination, reproduction, inheritance, evolution, ecology, and human health. In units two and three, especially, one feels uncomfortable in the stresses and strains that are created by the attempt at new patterns of integration. For example, symmetry, which has a multiplicity of connections in the context of animal classification, is put to work in relation to a chapter on adaptations of animals for securing food, where it is of only incidental service. Again, transportation and diffusion are discussed in relation to nutrition, are placed in the chapter titles, and are without references in the index to other subjects for which they possess as many or more connections. Because of the attempt to integrate transportation and nutrition, confusion is introduced concerning the nutrition of whole organisms and the nutrition of individual cells within complex organisms.

Units four to ten are more traditional and more orderly. If one were to say that they simply appear more orderly because they are traditional, then one must ask what is meant by order. Order means that subjects with multiple connections must be placed as close together as possible and that the multiple connections must be

disrupted with as few side issues as possible. Thus we find that the traditional presentation of diffusion and chemistry in an introductory chapter has a real reason for existence. It makes it possible for a more unified presentation of physiological subjects. Here, as in other pedagogical situations, the reshuffling of subjects is truly integration only if the tightness and multiplicity of connections between subjects is strengthened. Thus one finds, when it is examined from this view, that much of the so-called integration in the schools, in secondary schools especially, is in reality disintegration.

Each chapter is followed by a number of questions. Almost all of the questions seek answers to be derived by straight recall. No references are given. This should never occur, because teachers in a field as broad as biology always need reference material even if it is assumed that no students will want to go beyond the textbook. A long glossary of thirty-one pages adds much to the worth of the book.

RALPH W. LEWIS

BIOLOGY: HISTORY AND BIOGRAPHY

ASTROLOGY AND ALCHEMY. *Two Fossil Sciences.* *By Mark Graubard. Philosophical Library, New York.* $5.00. xi + 382 pp.; ill. 1953.

Students of the history of science, at least at the undergraduate level, tend to show considerable curiosity concerning the development and significance of both astrology and alchemy. Literature at a rather elementary level, which might serve as introductory either to the specialized scholarly treatises on these subjects or to the more recondite original writings, is unfortunately very sparse. Graubard's book might be considered an attempt to provide such an introduction.

The materials are drawn almost exclusively from secondary sources, which in itself is not necessarily disadvantageous for a textbook on this plane. They are not however always judiciously chosen. Of what significance is it to say of Copernicus, for instance (and I repeat in its entirety the quotation borrowed by Graubard from a 19th century history of astronomy), that "his instruments, which were mostly of his own construction, were far inferior to those of Nassir Eddin and of Ulugh Begh," when Nassir Eddin and Ulugh Begh are never otherwise mentioned or identified? The data, furthermore, are on the whole infelicitously organized. While many facts are enumerated, the dynamic processes which characterize the development of ideas have eluded treatment. Finally, the volume throughout labors far too vigorously the point that, to quote the first sentence in the book, "it has been customary to treat as folly and superstition many of man's past attempts at knowledge of nature or at understanding her phases and processes." This is no longer either necessary or opportune.

JANE OPPENHEIMER

FARWELLIANA. *An Account of the Life and Botanical Work of Oliver Atkins Farwell, 1867–1944. Bull. No. 34.* *By Rogers McVaugh, Stanley A. Cain, and Dale J. Hagenah. Cranbrook Institute of Science, Bloomfield Hills.* 75 cents (paper). iv + 102 pp. + 7 pl. 1953.

Oliver Atkins Farwell was for 41 years a botanist for a Detroit pharmaceutical concern, and spent the greater part of his active life collecting and studying the flora of Michigan. His collections covered a period of more than 60 years. Anyone who is familiar with those of our large herbaria that deal with temperate America will be familiar with his labels and notes, for he was a voluminous collector and botanical correspondent. The present book consists of four parts. The first is a general account of Farwell's life and work, with sections on his contributions to botany, his philosophy of nomenclature, the validity of his names, a review of his collections, and the nature of his types. The second part consists of a fully annotated list of the new taxa published by Farwell during his life. The third part is a list of new plant names proposed by Farwell but not yet listed in the standard bibliographic indexes. Finally, there is a bibliography of his published works.

The preparation of the volume, though a joint effort on the part of the authors, was subdivided among them as follows. The biographical sketch and the general report on the Farwell collection were written by Stanley A. Cain while he was botanist at the Cranbrook Institute of Science. The annotated list of new taxa, as well as most of the identifications and taxonomic conclusions contained in it, are the work of Rogers McVaugh of the University of Michigan. The latter also prepared the list of proposed names. The bibliography is primarily the work of Hagenah. The paper is illustrated with several photographs of Farwell, reproductions of his labels, handwriting, and annotations.

Among taxonomists Farwell has long been known as an eccentric in matters of nomenclature, and as the present authors indicate, something of a heretic. He was prone to give names and taxonomic significance to minor variations that have been considered trifling by most students. The present work will do much to clarify for present and future students the tangle of nomenclatorial problems that Farwell introduced.

H. M. RAUP

MY LIFE WITH THE MICROBES. *By Selman A. Waksman. Simon & Schuster, New York.* $5.00. xii + 364 pp. + 1 pl. 1954.

This is the autobiography of an emigrant from the Ukrainian steppes who came to this country "in search of a better education, of better opportunities." If only for his part in the discovery of streptomycin, the world is in his debt and has acknowledged this with many

honors. The author has put as the focal question: how did this discovery come to happen in his small academic laboratory of soil microbiology?

This is a matter-of-fact account, very much in the first person but not deeply introspective. Waksman's preoccupation with the microbes of the soil left him no time for other affairs of public interest, and his book takes little space for humor or drama or errantry, gives little insight into the creative process. It is a statement of spectacular personal and humanitarian success achieved by the rectilinear path of diligent attention to a concrete program. Two quotations are more illustrative of motif than typical of content:

"My usual reply [to the question how streptomycin was isolated] was as follows: 'No not quite! We went about it the hard way. We isolated freshly some ten thousand cultures of different microbes. These were tested for their activity against bacteria. Ten per cent of them were found to possess such potentiality, thus giving us a total of one thousand active cultures. The latter were now grown on various liquid media to find those which had the capacity to liberate freely the substances possessing such activity; ten per cent were found to yield such substances. This gave us one hundred promising cultures. Since the active substances produced by these cultures were unknown and they all required different chemical manipulations for isolation and purification, we finally succeeded in developing procedures for the isolation of ten per cent of them, thus giving us a total of ten new compounds. When these were tested for their therapeutic activity in animals, some were found to be too toxic, others were not very active in the body or did not possess the desirable kind of activity. Only one of these proved to be a successful agent, streptomycin.'"

And, to his assistants: "You are now witnessing a historical event. It is the first attempt that has ever been made to grow an actinomyces on a large scale, to attempt to utilize an actinomyces for any practical purpose, or even to find any use whatsoever for a member of this obscure group of microorganisms."

The book was written for a popular audience and little scientific detail is given. Informed readers will regret that the conclusions of soil microbiology are not stated more concretely. We do learn that many microbes interact in the soil, be it sym- or anti-biotically, and that the biochemical transformations they accomplish are of critical importance in defining the earth off which we live. But, while this briefly restates the theoretical foundation of Waksman's studies, ironically, some producers of antibiotics have found it advantageous for patent purposes to insist that antibiotic formation is a process which does not occur normally in the soil, but is an artifact of human technology.

There will be wide interest in the appalling situation that surrounded the notorious litigation over patent rights to streptomycin and the legal stipulation of its discovery. The freedom of academic research can be justified only by its standing as a public trust. How can this be reconciled with the incentive of personal gain from that narrow stratum of scientific achievement which can lead to patentable invention? The author has taken pains to emphasize the untraceable roots of every discovery; the account of his voluntary concessions subsequent to the settlement of the lawsuit tacitly implies his own acceptance of the same principle. At best, we may hope that this ugly lesson will help to provoke the means of discouraging the motive of personal profit in the academic research laboratory before it imperils the foundations of academic freedom. There are signs that the biochemical industries, in their own support of academic research, are equally concerned with the separation of fundamental and commercial interests.

Whether Waksman has answered his focal question must be left to the individual reader. It is likely that a definitive history of Waksman and his role in the development of chemotherapeutics will have to wait the objectivity of a disinterested student and the perspective of time.

J. LEDERBERG

GALEN OF PERGAMON. *Logan Clendening Lectures on the History and Philosophy of Medicine. Third Series. By George Sarton. University of Kansas Press, Lawrence.* $2.50. viii + 112 pp.; ill. 1954.

This short book represents a modification of one of the two Logan Clendening Lectures delivered by Sarton in 1952. One of the greatest inconsistencies in current study of the genesis of biological ideas consists in its virtual exclusion from adequate consideration of both data and interpretations concerning a figure whose concepts dominated not only western medical thought but also theological doctrine for as long as 1500 years. It is to be hoped that to the relative position of Galen's teleology, with respect to that of Aristotle before him and of medieval Christianity after, there will soon be devoted the full treatment it deserves; but meantime the brief statement by Sarton serves as necessary introduction. What is especially valuable in this book is that in it Galen becomes considerably alive, both as a person and as an individual in relation to his active moment in history. Like all of Sarton's contributions, this one is rather personally written, and somewhat fragmentedly; but it is informative, impeccably documented, and stimulating, and therefore to be highly recommended.

JANE OPPENHEIMER

THE FOUNDERS OF NEUROLOGY. *One Hundred and Thirty-Three Biographical Sketches. Prepared for the*

Fourth International Neurological Congress in Paris by Eighty-Four Authors.

Edited by Webb Haymaker; with the bibliographical and editorial assistance of Karl A. Baer. Charles C Thomas, Springfield, Ill. $10.50. xxviii + 480 pp.; ill. 1953.

The neurologists chosen for the brief biographical sketches which make this book are those whose labors are written large in indelible print. It is a joy to read of their training as young men and to note that the majority were given academic preferment suitable to their ability and accomplishments. There were others, however, who, in spite of their contributions to the understanding of the nervous system, were passed over by the promotion committees of their day. That these 133 men sprang from every condition of life, characteristic of their time and country, is heartening and speaks well for democracy within the subject they created.

To a neurologist the photographs of these men are the most delightful aspect of the book, for, at last, the name attached to a part or to a function of the nervous system may be associated with the features of the man who saw it. In spite of the large number of neurologists (84) and the classification of these men as neuroanatomists, neurophysiologists, neuropathologists, clinical neurologists, and neurosurgeons, there is a satisfying unity in the short presentations of their biographies. Within these separate groups the founders appear in alphabetical order, making it easy to find a given name but detracting definitely from the historical sequence of their contributions. Each reader will, therefore, find it necessary to reconstruct the order of these sketches before the development of neurology can emerge. This book is invaluable for any serious student of the nervous system; and such students are accustomed to recreating their own sequences according to the logic demanded by their own central nervous systems.

MARION HINES

THE YOUNG NATURALIST

BIOLOGIE. *Two Volumes.*

By Karl von Frisch. Bayerischer Schulbuch-Verlag, München. DM 7.80 each. (I) 191 pp.; ill. (II) 201 pp.; ill. 1952.

To those who have read in their English translations any of Karl von Frisch's books on bees, it will come as no surprise to learn that he is a master of clear, lucid exposition and superb style. Long ago he wrote for the layman a book on biology, *Du und das Leben*, which unfortunately was never translated into our language. Now he has turned his hand to the preparation of a matchless textbook for students of biology in the upper schools, the equivalent in the United States of many an elementary college course. Von Frisch's inclination was to write a book "to make life living and to open young eyes to all that is wonderful and worth knowing around us and within us; a book that would not be learned by heart, but one in which the student would from his own desire read more than the teacher assigned and which perhaps might also become a companion outside the school. . . ." Never has there been a textbook so beautifully illustrated, with pictures and diagrams in contrasting color and line drawings of elegance and beauty; and never has there been such a clear portrayal of what is significant and what is interesting in biology. Until it is translated into English to take its rightful place as the peer of secondary school textbooks, it may well serve biology graduate students not only in their effort to acquire a vocabulary in the field and a knowledge of constructions, but also to acquaint them with German scientific style at its best. How different from the involved, turgid sentences of most scientific writing, whether in German or English!

Volume I contains only three sections. The first consists of an introduction to the cell—and where better can a biologist start? It is very interesting to see that von Frisch does not think this approach too difficult or unfamiliar to the young student, but on the contrary one full of strange fascination. The second part is a very brief consideration of tissues. The greatest part of the first volume is devoted to the organs and their functioning, beginning with the skin, skeleton, and organs of locomotion, then passing to the organs of nutrition and metabolism, respiration and circulation, and finally taking up the sense organs, nervous system, and endocrine glands. There is only a slight amount of attention in this first part of the textbook to plant life. The treatment frankly makes use of the natural interest in the human body, but supplies a strong element of the comparative approach and gives the necessary attention to fundamental concepts at the beginning.

Volume II has six principal sections. The first deals with adaptation, and is full of interesting and bizarre information and striking examples that any teacher might profitably use to enrich his own presentation of biology in classroom or laboratory. A longer section deals with the interrelationships between organisms. Parasitism, symbiosis, camouflage and mimicry, and social organization among animals are sketched in a fascinating array. The next section deals with mating behavior and reproduction; the fourth, with development; the fifth, with heredity; and the last, with evolution. Each part is presented with authoritative accuracy, and each seems equally illumined by a rare and genial spirit.

Neither book is large—a mere 200 pages, perhaps a third of which is occupied by the illustrations. It is truly astounding how much has been communicated in so short a text, which reveals in every line the master teacher. Is it conceivable that in this country a biologist of the stature of von Frisch would devote himself to the preparation of a biology textbook for the secondary

schools? And if he did, is it conceivable that he would know how to do it well?

BENTLEY GLASS

SCIENCE NEAR YOU.

By Gerald S. Craig and Bernice C. Bryan. Ginn & Company, Boston, New York, Chicago, Atlanta, Dallas, Columbus, San Francisco, Toronto, and London. $1.88. 96 pp.; ill. 1954.

SCIENCE AROUND YOU.

By Gerald S. Craig and Etheleen Daniel. Ginn & Company, Boston, New York, Chicago, Atlanta Dallas, Columbus, San Francisco, Toronto, and London. $2.16. 144 pp.; ill. 1954.

SCIENCE EVERYWHERE.

By Gerald S. Craig and Marguerite W. Lembach. Ginn & Company, Boston, New York, Chicago, Atlanta, Dallas, Columbus, San Francisco, Toronto, and London. $2.24. 160 pp.; ill. 1954.

DISCOVERING WITH SCIENCE.

By Gerald S. Craig and Beatrice Davis Hurley. Ginn & Company, Boston, New York, Chicago, Atlanta, Dallas, Columbus, San Francisco, Toronto, and London. $2.40. 264 pp.; ill. 1954.

ADVENTURING IN SCIENCE.

By Gerald S. Craig and Katherine E. Hill. Ginn & Company, Boston, New York, Chicago, Atlanta, Dallas, Columbus, San Francisco, Toronto, and London. $2.52. 288 pp.; ill. 1954.

The introduction of science into all grades of schooling is becoming an accepted element of our educational system. Certainly the spark of interest is in the students, and the world is full of interesting things, so there can be little room for argument as to the desirability of introducing the student to the biological and physical world about him. These books, which, in the order listed, are intended for the first through the fifth grades, do this quite nicely, with increasing complexity introduced by a change of subject matter, an increasing amount of detail, and a shift from pictorial to written description. Additional members of this series cover from the primer level to the eighth grade, and maximum use of them as teaching material depends upon the adoption of the entire series. Teaching manuals accompany each volume.

FREEDOM AND PLENTY: OURS TO SAVE.

Written and illustrated by Wilfrid S. Bronson. Harcourt, Brace and Company, New York. $2.95. iv + 124 pp.; ill. 1953.

This is a book on the conservation of our natural resources, written for the young reader. A sharp contrast is drawn between the utilization of resources during our period of expansion in America, when exploitation was the order of the day, and the necessity for wise and careful use and replacement of our dwindling reserves today. The role of resources in the economy of our country is emphasized, and the steps taken by the government to conserve and replace them are described. Like other books by W. S. Bronson, this one is well written and illustrated, and the points to be made are neither magnified out of proportion nor distorted in an effort to emphasize.

C. P. SWANSON

ECOLOGY AND NATURAL HISTORY

NORTH AMERICAN PRAIRIE.

By J. E. Weaver. Johnsen Publishing Company, Lincoln. $5.00. xi + 348 pp.; ill. 1954.

J. E. Weaver, of the University of Nebraska, has been a keen student of the North American grassland during the better part of his active career. As he states in his Preface, he has spent forty summers studying the prairies, and dealing with the myriad problems that have arisen with the increasing intensity of our use of the grasslands. He has been a prolific contributor to journals and other publications through the years; and in the present volume he attempts to gather together the net results within the covers of a single publication.

The book consists of 16 chapters, the first 9 of which deal mainly with the general nature of the prairies and their plant inhabitants. The remaining 7 chapters describe changes that have occurred since the time of settlement. Chapter 1 is introductory, and includes sections on the origins and extent of the prairie, its general environmental conditions, the structure and general arrangement of types of prairie, and methods of study. Chapters 2 to 5 inclusive describe the principal grasses and non-grass species in lowland and upland communities. The sixth and seventh chapters are devoted to the structure and behavior of roots and rhizomes of prairie species. Weaver has long been well known for his meticulous studies of root systems, and much is compressed into these two chapters. Chapter 8 is concerned with seasonal aspects, the relation of prairie plants to erosion and rainfall interception, and to the effects of artificial removal of the plant cover. Chapter 9 is on plant-soil relationships. The tenth and eleventh chapters deal briefly with the history of settlement, description, and research in the eastern and western sections of the prairie, while the next 3 chapters are devoted to the effects of drought, with special attention to the great drought years of the early 1930's. The last 2 chapters of the book describe the processes of grassland degeneration, their causes, and the problems of rehabilitation. At the end of the book are lists of common and scientific names used, cited literature, an index to authors mentioned in the text, and a general index.

The book is beautifully printed, in relatively large type, and is illustrated profusely with line drawings, charts, maps, and half-tone reproductions of photographs. Considerable parts seem to have been taken directly from published papers dealing with specific research projects. These appear suddenly in the course of general discussions, involving changes of "pace" in space and time relations. One could wish that these had been smoothed over. The area covered apparently involves what are commonly thought of as the tall grass and mid-grass prairies, which seem to correspond to Professor Weaver's eastern and western sections. Most of the research reported, however, is from the western section.

The basic media of interpretation that appear throughout the work are the theories of the closed community, natural succession, and climax. It is conceived that prior to the invasion of the white man the prairie consisted of essentially stable climax communities, "... the outcome of thousands of years of sorting of species and adaptations to soil and climate. Grassland soils through untold centuries have been thoroughly protected by the unbroken mantle of prairie vegetation." The author looks upon the prairie as "... much more than land covered with grass. It is a slowly evolved, highly complex organic entity, centuries old. It approaches the eternal. Once destroyed, it can never be replaced by man."

If one questions these basic concepts, much of the book has to be reinterpreted. The actual descriptions of the grasslands are superb, but to extricate them from the maze of interpretation is not always easy. Another book (1947) on *The Grassland of North America*, by Prof. James C. Malin of Kansas University, seriously questions the above theories. Malin suggests that the grassland was never stable, and never developed a climax in the usual sense of the term. He suggests that this vegetation should be thought of as an "open system" in which there is endless change both in time and space, much of it brought about by factors external to the vegetation. As a historian, he marshals an impressive mass of fact in support of that idea. Curiously, neither this book nor any of Professor Malin's other papers on grassland historical studies are mentioned in *North American Prairie*. In my own opinion students of the grassland would profit greatly by reading the two books in close sequence.

H. M. RAUP

THE WILDERNESS WORLD OF JOHN MUIR. *With an Introduction and Interpretive Comments.*

By Edwin Way Teale; illustrated by Henry B. Kane. Houghton Mifflin Company, Boston. $4.50. xx + 332 pp.; ill. 1954.

John Muir wrote continuously of the places he visited, and in days when walking rather than riding was the vogue he probably saw more of our natural wilderness than any other man. And he saw this through eyes that were trained to see and a mind that could assimilate and appreciate. Much of what he wrote, however, was bad, and has no real place on a shelf of good literature. Only judicious selections could weed out from the welter that which is good by any standard, and this Edwin Way Teale has attempted to do. Most of the selections deal with Muir's descriptions of aspects of the Sierras, but others deal with his boyhood in Scotland, a visit to Cuban waters, and his Alaskan trips. Particular emphasis is given to his 1000-mile jaunt through the southeastern part of the country.

From these writings we can get an idea of Muir, the man, as well as of Muir, the naturalist. Little escaped his attention, and of that very little escaped his pen. This is not a book, however, to be read through in one or two sittings. Taken a chapter at a time Muir reads well; in big doses he will become monotonous, for he lacked the gift of dramatic writing, the ability to turn a good phrase, and the touch of spontaneity that makes for great prose. The value of his writings lies more probably in the glimpses he affords us of an America untouched as yet by advancing man, and for this reason Muir's books, and these selections, have a rightful place in the literature of natural history.

C. P. SWANSON

LIFE IN LAKES AND RIVERS.

By T. T. Macan and E. B. Worthington. Frederick A. Praeger, New York. $4.50. xvi + 272 pp. + 72 pl.; text ill. 1954.

This volume of the New Naturalist Series maintains the high quality of the other issues. It describes in clear, concise language and with ample figures the animals and some of the plants that occur in the lakes and rivers of Britain. Basic biological principles are neatly woven into the text in an accurate and unpretentious manner. The book will be highly useful to Americans who wish to know something about the distribution of aquatic animals in Britain and also the characteristics of British lakes and rivers. It does not pretend to develop new principles or add new information. The colored plates are excellent, and the list of references will be helpful.

DAVID E. DAVIS

THE NATURAL REGULATION OF ANIMAL NUMBERS.

By David Lack. Oxford University Press, London; [Oxford University Press, New York]. $5.60. viii + 344 pp.; ill. 1954.

This is a curious book. At first sight, the table of contents appears to be a disjointed series of chapters on birds, with a few comments about other animals thrown

in. Yet actually the author has used the abundant information about birds to discuss the general problems of the regulation of populations. He first calls attention to the fact that many natural populations remain about the same for long periods of time. Then he discusses the data available in regard to the reproduction of birds and thereafter in regard to mortality. Lastly, he discusses food and predation as limiting factors, along with some miscellaneous topics such as cycles and climate.

Several general comments seem desirable. The book does not set forth a clear scheme for the comprehension of the regulation of animal numbers. Food is emphasized as an important factor but predation is also mentioned. No distinction between limiting and governing (controlling) factors is made, and confusion thus continues on this point. The lack of mathematics is probably in deference to the mathematicophobia of biologists, but perhaps mathematical treatment would nonetheless clarify the concepts.

The role of competition should be more amply discussed in a book that deals with the regulation of populations. Indeed, a book with this general title should have discussed many other topics than it does. The extensive knowledge of fish populations has been almost entirely ignored. There is little discussion of methods. However, these comments are directed at the unwise choice of an all-inclusive title (a practice all too common) rather than at the author's decision to exclude those topics. The reader may expect to get from this work an excellent summary of information about bird populations rather than a coherent theory of population regulation.

A few minor points may be mentioned. Lack refers to "unnatural" populations (interfered with by man)—but where is there today a "natural" population? The statistical significance of quoted data is not regularly evaluated (e.g., p. 108). Predation and disease are discussed as though they were different factors, although their roles in population regulation are in principle the same. Nor can I resist the temptation to point out that Baltimore (where the *Quarterly Review of Biology* is edited) is not a "part of the city of Washington" (p. 70)! The book is excellently printed, has a minimum of typographical errors, a fine bibliography of 1000 titles, and splendid indices to species, author, and subject. It will be very useful to biologists who wish to find data about bird populations.

DAVID E. DAVIS

ELEMENTS OF ECOLOGY.

By George L. Clarke. John Wiley & Sons, New York; Chapman & Hall, London. $7.50. xiv + 534 pp.; ill. 1954.

This textbook is designed primarily for the marine ecologist. Although called "elements" of ecology, half the chapters deal largely with marine aspects. These chapters give an excellent summary of the habitat: substratum, water, temperature, light, gases, and nutrients. The rest of the book discusses relations among species and community aspects. The abundant illustrations (193) clarify the text, and the index seems definitely adequate and accurate. There are nearly 500 references.

As is so often true, one finds here only a brief treatment of principles of general biological interest. For example, the predator-prey problem is covered in about 10 pages, including a discussion of sustained yield, and other general problems are treated equally briefly. The author also apparently acquiesced to the mathematicophobia of biologists and omitted almost all equations. In spite of this aspect, this book can be recommended as a thorough and careful description of many aspects of ecology, especially the marine.

DAVID E. DAVIS

THOSE OF THE FOREST.

By Wallace Byron Grange; illustrated by Olaus J. Murie. The Flambeau Publishing Company, Babcock, Wisc. $4.75. iv + 314 pp.; ill. 1953.

This is in many respects a rare and wonderful book. Words flow over the printed page with a kind of hypnotic rhythm and beauty, yet without seeming to blur the kaleidoscopic picture of nature that is being held up to view. It can be read for its literary qualities alone, for it is prose from the pen of a master craftsman; it can likewise be read for its scientific import, for it reveals the ecology of the seasons and the balance and interdependence of many lives more exactly and more convincingly than any textbook of which I am aware.

The book, in essence, deals with the balance of nature as it shifts with the seasons, and with the fact that no change, be it gradual or catastrophic, occurs in a natural environment without having an impact on almost every level of organic existence. The thread of the story is the life of the snowshoe rabbit, but it could equally well have been the life of the snowy owl that is ever on the alert to snuff out the rabbit's life that the owl fledglings might live, or of the botfly that causes the rabbit so much annoyance and pain as it lies embedded in the muscles of his back, or for that matter of the beaver in his island castle. Life and death, plentitude and disaster march across each page. Individuals die that their predators might live, but the species continue, for the loss of one would interrupt the chain of life that goes on endlessly. To handle the welter of detail without loss of continuity is difficult indeed, but the author manages to do this with a fine sense of proportion and humility, and with an almost complete absence of sentimentality or moralizing. It is a book to buy, to keep, and to read again and again.

C. P. SWANSON

MATING BEHAVIOR PATTERNS IN TWO SYMPATRIC SPECIES OF XIPHOPHORIN FISHES: THEIR INHERITANCE AND SIGNIFICANCE IN SEXUAL ISOLATION. *Bull. Amer. Mus. Nat. Hist., Vol. 103, Art. 2.*

By Eugenie Clark, Lester R. Aronson, and Myron Gordon. American Museum of Natural History, New York. $1.50 (paper). Pp. 135–226 + 10 pl.; text ill. 1954.

Interspecific mating of related sympatric species is usually inhibited by a complex of individually incomplete but collectively effective isolation mechanisms rather than by one single, all-important mechanism. Critical field and/or laboratory observation and experimentation are necessary to elucidate such a complex of isolation mechanisms. This research report from the Department of Animal Behavior at The American Museum of Natural History is the result of a critical study made mostly under laboratory conditions.

The swordtail (*Xiphophorus helleri*) and platyfish (*Xiphophorus maculatus*) occur together in many places in their ranges in eastern Mexico and Central America. Swordtails, with the widest distribution, have been found in each of the 7 river systems in which platyfish have been found, but not always in exactly the same habitat. Interspecific hybrids can be produced through "no-choice" matings in the laboratory. No natural hybrids have been revealed, however, in the examination of some 7000 field-collected specimens. It is concluded that isolation of the two species in nature seems to be complete due to the combined effects of a series of isolation mechanisms.

The two species are incompletely separated ecologically by the preference of swordtails for swift headwaters and of platyfish for more slowly flowing lowland streams. Both were taken together, however, at about one-fourth of the collecting stations, and in the rainy seasons swordtails from the headwaters are likely to be swept downstream into platyfish populations. Where the two kinds occur together, a second group of isolation mechanisms would come into play. These physiological isolation mechanisms are categorized as: (1) differences in sensory apparatus, (2) differences in thresholds for sexual response, (3) emotional differences, (4) differences in sexual behavior, (5) functional morphological differences, and (6) differing responses due to individual experiences. Much of the report is devoted to the measurement of various phenomena of sexual behavior. The courtship behavior patterns of "pecking" and "retiring" typically shown by male platyfish were never seen in male swordtails. The latter showed patterns referred to as "exaggerated backing" and "nibbling," which were not seen in platyfish. If both ecological and physiological isolation fail, gametic isolation, including less viability of sperm in the oviduct of the heterospecific female and competition between homospecific and heterospecific sperm, comes into play. If all other mechanisms fail, genetic isolation mechanisms of hybrid inferiority and partial hybrid sterility provide the final barrier to interspecific gene exchange.

Single-shot isolation mechanisms, such as the "lock and key" concept based on gonopodial differences, and the destructive melanomas which appear in platyfish-swordtail hybrids, are discounted. The barrier to gene exchange is regarded as the sum of a number of partial barriers, each of which reduces to some extent the probability of hybridization.

The inheritance of some behavior patterns was followed through F_2 and backcross generations. Some ingenious techniques were developed. An electrically controlled polygraphic recording apparatus was devised to record the duration and sequence of each behavior in a test period. The machine was operated by a "touch-type" system. Gonaductal smears were taken from living females with a micropipette after all critical observations to determine whether or not insemination had occurred.

This report presents a well documented picture of the evolved and evolving isolation mechanism complex that prevents interspecific hybridization between the platyfish and swordtail. It is equally valuable as an illustration of the kind of work needed if there is to be a clear understanding of how species restrict gene exchange in nature and thus maintain their separate identities.

W. FRANK BLAIR

SEA-BIRDS. *An Introduction to the Natural History of the Sea-Birds of the North Atlantic.*

By James Fisher and R. M. Lockley. Houghton Mifflin Company, Boston. $6.00. xvi + 320 pp. + 48 pl.; text ill. 1954.

The sea-birds of this volume are those of the Atlantic, north of the equator. No team of authors could be better equipped to write of them. Lockley has lived for years on Atlantic islands, in Wales, and elsewhere, and is the author of a series of volumes based on these experiences, volumes that are as highly regarded for their literary merit as for their authentic natural history. James Fisher, best known, perhaps, for his monograph of the fulmar, a northern relative of the albatross, is an enthusiastic student of the geology and wildlife of the picturesque coasts and islands of the North Atlantic.

The present volume, then, is based on a wealth of first-hand field experience. Equally thorough has been the organization and presentation of the printed results. The avifauna of each subdivision of the Atlantic is analyzed to explain, in so far as possible, its composition in terms of ecology and of historical and evolutionary factors. Then there are chapters on the general behavior of oceanic birds and on the factors, human and otherwise, regulating their populations.

The impact of man upon the once teeming colonies has been great—sometimes causing drastic declines, and even, as with the great auk, total extinction; while

in other instances the growth of seaports, with their garbage dumps and fish markets, has permitted tremendous increases, as in the gulls and fulmars.

A final distinction of this excellent book is its wealth of good photographs, both in color and black and white (the British edition is one of the New Naturalist series, noted for fine illustrations). The frontispiece, a painting by R. T. Peterson, is of a nearly extinct petrel, the cahow, of Bermuda.

DEAN AMADON

HIGH TIDE AND AN EAST WIND. *The Story of the Black Duck.*

By Bruce S. Wright; line drawings by Peter Ward, courtesy of the Frederic C. Walcott Memorial Fund of the North America Wildlife Foundation. The Stackpole Company, Harrisburg; Wildlife Management Institute, Washington. $4.50. xiv + 162 pp. + 16 pl.; text ill. 1954.

Not much is written here about the Black Duck, but the author takes a depressing glance at the instability of the fauna and flora of Eastern Canada. Bruce Wright was employed to find out how things might be better ordered in Canada to assure ducks for U. S. hunters. The shooting of wild ducks for sport is referred to in the book as "harvesting the crop." Wright found nothing wrong with conditions in Canada, yet. "In an area of 600,000 square miles no management was needed until" the discovery of iron ore in 1945 began to open up the country and to "seal the doom of the wilderness" that has been, among other things, "the Black Duck's main stronghold," where it has been breeding since "the end of the Ice Age . . . as completely oblivious of the presence of man as it would on the moon, because over most of that great area there were no men present during the breeding season." Wright suggests that much could be done to order the affairs of the Black Duck better in its winter grounds in the United States. "The legal take" is "the greatest single drain on the species." He wonders what will happen when numerous parties of businessmen visit the breeding waters by plane in order "to hunt for recreation."

H. ANSLEY

THE PASSENGER PIGEON. *Its Natural History and Extinction.*

By A. W. Schorger. The University of Wisconsin Press, Madison. $7.50. xiv + 424 pp.; ill. 1955.

This monograph is a condensed and readable review of the author's special collection of over 2000 references pertaining to this famous case. Each item considered is evaluated with objective care. There are 12 chapters on the natural history, anatomy, and behavior of the bird, and 4 on its extinction. The book is full of facts which are little known, and conclusions which are satisfyingly just and in some instances quite original.

It is little appreciated today, for instance, that the passenger pigeon had in its day a "bad press" and that public opinion was strongly against it. The exploitative activities which caused its extinction were engaged in with the enthusiasm and general approval given to all of our attempts to eradicate a pest. This is probably closely related to the fact, surprising to me, that "no other species of bird, to the best of our knowledge, ever approached the passenger pigeon in numbers. . . . It is possible that at one time this pigeon formed 25 to 40 per cent of the total bird population in the United States." Even the Audubon Clubs and conservationists made no effort to save it until ten years after it had become totally extinct, "despite the fact that the end came quite gradually and not with catastrophic suddenness as is popularly believed." The conscienceless reassurances of such responsible authorities as William Brewster make a fascinating record. Even after the bird was gone forever, his complacency led him to declare that he did not believe it, a belief which is still widely shared, as were his earlier pronouncements that the bird was in no danger. Illustrations are few but very select and adequate.

HUDSON ANSLEY

BIRDS THE WORLD OVER *as shown in Habitat Groups in the Chicago Natural History Museum.*

By Austin L. Rand and Emmet R. Blake. Chicago Natural History Museum, Chicago. $1.50 (paper). 96 pp.; ill. 1954.

By walking through the Hall of Habitat Groups of Birds in the Chicago Natural History Museum, the observer sees not only the birds but also the characteristic physiographic and floral aspects of the region where the bird has its home. This publication describes the habitat groups and serves as a layman's introduction to bird distribution. It is not merely a catalog of exhibits but a guide to the biological meaning of zoogeography and to the ecological relationships of birds to their habitats. To this end, the faunal regions of the world are described. The Museum is fortunate enough to have each faunal region represented by at least one habitat group; the Holarctic and the Neotropical have the best representation. Each exhibit has been photographed, something is told about the ecology of the birds to be seen in the exhibit, and consequently one does not actually have to be at the Museum to derive some useful information from this publication.

HENRI C. SEIBERT

ANIMAL COURTSHIP.

By Maurice Burton; drawings by Jane Burton. Frederick A. Praeger, New York. $4.00. 268 pp. + 7 pl.; text ill. 1953.

Maurice Burton is a British zoologist who writes precisely about such courtship subjects as dances, plumage, pursuit, and territory. His emphasis is on the similarity to human behavior, and he is strongly impressed by the need for choice of mating partners. As Deputy Keeper of Zoology at the British Museum of Natural History, he has taken advantage of opportunities to explore the literature and to accumulate notes particularly about animal behavior in zoos. Apparently he intended to include pertinent references on p. 264 and actually so listed it in the table of contents; but page 264 in our copy is blank, and followed by a brief index. The book is full of interesting information.

LORUS J. & MARGERY J. MILNE

A FIELD GUIDE TO ANIMAL TRACKS. *The Peterson Field Guide Series.*

By Olaus J. Murie. Houghton Mifflin Company, Boston. $3.75. xxiv + 374 pp.; ill. 1954.

The ninth handbook in the Peterson Field Guide series is by one of North America's distinguished outdoor men. It illustrates and provides fresh information not only on the tracks of mammals, birds, and various smaller animals, but also suggestions for recognizing them from their toothprints, droppings, and sounds. Olaus Murie's sympathetic understanding of wild life is evident from cover to cover. His many personal comments from his own experiences and travels enliven the text. There are more than 1000 illustrations, with a simple key to the tracks themselves. Every field man will want a copy for repeated reference.

LORUS J. & MARGERY J. MILNE

AN ANGLER'S ENTOMOLOGY.

By J. R. Harris. Frederick A. Praeger, New York. $5.00. xvi + 268 pp. + 48 pl.; text ill. 1954.

This book is volume 25 in The New Naturalist Library. The aim of this attractive series is "to interest the general reader in the wild life of Britain by recapturing the inquisitive spirit of the old naturalists." American naturalists and fly-fisherman, like their brothers overseas, will find this handsomely illustrated book delightful reading for those long winter evenings when streams are locked under ice and mayflies lie dormant at 4°C. close to the bottom of their lakes.

In two respects the book sets a standard of excellence that cannot be matched in similar books on this side of the Atlantic. The illustrations include over 30 excellent *colored* plates, mostly of various species of insects, plus some 15 black and white glossy plates, surely prize-winners, reproducing scenes ranging from the quiet pastoral charm of the river Test at Stockbridge to the dramatic sweeps of remote Loch Rannoch. On the taxonomic side matters are handled with a straightforwardness and competence that is refreshing. The insects discussed are divided into the Exopterygota and Endopterygota and the importance of so doing is explained. At the same time there is no parade of Latin or Greek for its own sake. Common names are given when they exist.

The bulk of the book consists of 11 chapters on the Ephemeroptera covering classification, distribution, behavior, and life history. A second part covers other insects such as caddis and stone flies, while the third concerns a variety of topics under the general heading of "Flies and Fish." An appendix includes keys to Ephemeroptera, distribution maps, fly dressings, and a bibliography.

G. B. MOMENT

THE MATING INSTINCT.

By Lorus J. and Margery J. Milne; illustrated by Olaus J. Murie. Little, Brown & Company, Boston. $4.50. xii + 244 pp.; ill. 1954.

THE SEX LIFE OF WILD ANIMALS. *A North American Study.*

By Eugene Burns. Rinehart & Company, New York. $3.00. xiii + 290 pp. 1953.

The Mating Instinct treats the sex life of animals in a popular vein, and thus we have two books of this kind, the other being Eugene Burns' *The Sex Life of Wild Animals.* Mr. Burns, a layman, is pitted here against professional zoologists of high academic rank. The two books bear comparison. Mr. Burns' treatise I read from beginning to end without embarrassment and with a continual sense that he was teaching me worthy facts and suggesting important ideas for investigation. His is informative writing in a fine, sober mood. By contrast Prof. Milne and his wife affect a flippant tone, yet their book is not nearly as readable. Their prose suffers not only from graceless prolixity, but also from the very tendency toward glib exaggeration and half-truth which Mr. Burns was able to avoid.

Like Mr. Burns, the Milnes, too, suggest ideas for scientific investigation, but unlike his, their suggestions often scarcely seem worthwhile for the undertaking. They suggest, for instance, that although in bats the males are smaller than the females, this difference, though obvious "to man's more critical eye," may not be apparent to a bat. They propose, as a valuable contribution to science, a project to discover whether the supersonic "voice of either sex [of bats] changes at sexual maturity as does the voice of man."

In addition, the Drs. Milne suffer from what may be a special problem of scientists when engaged in popular writing, in that they fail to appreciate what of their store of knowledge is little known (and therefore worthy of elaboration) and what is common knowledge. Passing (not to say puzzling) reference is made to "the *Esquire*-like eyes of a firefly" (the sex not mentioned). On the

other hand a paragraph is begun with solemn statement of the fact that some kinds of "eggs may be large enough to see with the unaided eye." The Milnes have a vast file of wonderful material and are much more learned than Mr. Burns, but where he succeeded in enlivening abstruse topics, they manage to spoil good stories. Always after finishing a chapter, I wondered what the theme had been. Dazzling displays of erudition (often incomprehensible, I am sure, unless the reader is equally well informed) are mingled with a remarkable jumble of pronouncements as from on high.

Writers on this subject run the risk of offending a reader's sense of propriety. In this respect Mr. Burns is a model author. Oddly enough, the professional zoologists seem frequently ill at ease. Let me hasten to say that no reader could help perceiving that the Milnes are models of propriety. But at first I was puzzled. Under the gay and flaunting banner of the first chapter—"Vive la Difference!"—one reads of "the difficult task of finding a mate in the dark," a statement I could question, and which only a very witty author might safely make. But my expectation of fun to come was soon dashed. The subject was not pursued. Another instance: "Robins do not always chase robins—regardless of sex.... During autumn migrations... whole bands flock together in interdependent unity." The suspicion is raised that the Milnes are not being wicked, or even naughty. Yet in that case they should not write " 'Sex is such a crude, raw word for such a lovely pastime,' is indeed an apt statement." Perhaps the worst treatment meted out by them is to the great G. B. Shaw. "George Bernard Shaw," they write, "has been quoted repeatedly for his complaint that youth was too wonderful a thing to waste on the young. Sex," they continue, "escapes that difficulty. Only with acquirement of final body development do the sexual instincts and abilities come to the fore." What puzzles me is why, if they suppose Shaw was discussing pre-adolescence, they quote him at all. Surely there is something of interest here for the amateur student of the psychology of that strangest of all animals, the academic jokester.

H. ANSLEY

EVOLUTION

GESCHICHTE DER WIRBELTIERE.

By Emil Kuhn-Schnyder. Benno Schwabe & Company, Basel. S. Fr. 14.00. 156 pp. + 12 pl.; text ill. 1953.

This treatment of vertebrate history has much to recommend it. Although moderate in length, it is sufficiently detailed to give depth to the well-told story. The text is amply illustrated with drawings of uniformly high quality, artists' reconstructions of prehistoric life, and photographs of some of the men who made important contributions to the field. There are a number of excellent charts showing lines of evolutionary descent for the main groups.

Each chapter is carefully annotated to ease the way for the reader not versed in comparative anatomy, embryology, or paleontology. Incorporated into the notes are biographies of 76 men, from Aristotle to Robert Broom, whose work and thought form the fabric of this account.

Chapters on the nature of fossils, the concept of geologic time, and the basic vertebrate plan precede the treatment of the main vertebrate classes. The final chapter concerns the evolution of man. This book will serve equally well as an introduction to the subject or as a comprehensive review.

FRANK C. ERK

PALEONTOLOGY AND MODERN BIOLOGY.

By David Meredith Seares Watson. Yale University Press, New Haven. $4.00. xii + 216 pp.; ill. 1952.

In 1937 the distinguished English zoologist and paleontologist D. M. S. Watson was appointed to give the annual Silliman Memorial Lectures at Yale. It was planned to publish the lectures promptly in book form, and a manuscript was prepared. Storm clouds, however, were then gathering over Europe, and Prof. Watson soon became so deeply involved in work for his government that it was not until 15 years later that the work could be completed and finally published.

Watson had chosen as his major theme the structural changes seen in the evolutionary history of the lower vertebrates and the light which these paleontological problems shed on evolutionary and other general biological problems. The discussion as a whole gives the reader insight into the intellectual processes underlying paleontological work, and the examples used are mainly from the author's own researches, ranging from ostracoderms and acanthodian fishes to the ancient labyrinthodont amphibians and mammal-like reptiles.

Paleontology is one of the older biological disciplines, dating essentially from the days of Cuvier a century and a half ago, and hence is less subject to rapid radical changes in its concepts and data than are newer areas, such as biochemistry or genetics. Watson's book, however, shows with unusual clarity the fact that even in this supposedly staid field advances are still occurring at a relatively rapid rate. The common procedure for bringing a manuscript of this sort up to date is that of incorporating new data in the original manuscript. Watson has, in contrast, preserved the original text of his lectures, but added to each lecture chapter an appendix which includes the new facts which have come to light during the war period and the changes in his concepts which have resulted from them. These appendices form an appreciable portion of the whole; indeed, in one instance the appendix is longer than the

original lecture. We thus have in this work the unusual privilege of viewing under one cover both a subject and a brilliant worker in it, in two successive stages of development.

A. S. ROMER

LOWER TERTIARY FORAMINIFERA OF THE QATAR PENINSULA.

By Alan Hilder Smout. British Museum (Natural History), London. £2.5s. x + 96 pp. + 15 pl.; text ill. 1954.

The Foraminifera discussed in this excellent and stimulating monograph were obtained from five deep wells on the Qatar Peninsula of Arabia situated on the Arabian shore of the Persian Gulf, southeast of the Island of Bahrein. Strata of Maestrichtian, Paleocene, Lower and Middle Eocene are identified on the basis of foraminiferal data.

The systematic portion of the report is largely concerned with the superfamily Rotalidea (family Rotaliidae and family Nummulitidae), superfamily Discorbidea (family Amphisteginidae and family Planorbulinidae), superfamily Miliolidea (family Alveolinidae) and superfamily Lituolidea (family Orbitolinidae). The superfamily Rotalidea as redefined by Smout includes a different generic assemblage than the Rotalidea Reuss, 1860, and is a much smaller superfamily than that proposed by Glaessner in 1945. It includes the following families: Rotaliidae, Nummulitidae, Elphidiidae, Calcarinidae, Rupertiidae, Orbitoididae (part), Miogypsinidae, and Discocyclinidae. It excludes the families Spirillinidae, Discorbidae, Nonionidae (part), Amphisteginidae, Orbitoididae (part), Cymbaloporidae, Globigerinidae, Globorotaliidae, Gümbelinidae, and Planorbulinidae that were included by Glaessner in the superfamily. Smout thus excludes genera traditionally associated with *Rotalia* but in reality not related to that genus. The majority of genera excluded have considerable superficial resemblance to *Rotalia* but have single septa, or lack traces of a septal flap and have no canals. The superfamily Discorbidea is named as a group to parallel the Rotalidea and to include the Discorbidae, Amphisteginidae, Cymbaloporidae, Planorbulinidae and perhaps the Globorotaliidae. The distinguishing features of this superfamily in contrast to the Rotalidea are the absence of canals and the doubling of septa.

The characters of the test, classification, morphogenetic principles, and evolution of the superfamily Rotalidea are ably discussed and illustrated. The systematic portion of the paper includes lucid descriptions of the genera and species described. Keys are given for the various genera. In a monograph such as this, it is surprising, however, to find types cited for genera, without a statement of how these types were fixed. The following genera are described as new: *Kathina* (type: *K. delseota* Smout), *Dictyokathina* (type: *D. simplex* Smout), *Daviesina* (type: *D. khatiyahi* Smout). The illustrations are presented on 15 collotype plates containing many excellent photographs, although occasional illustrations tend to be fuzzy and out of focus, perhaps because the sections were too thick to make clear photographs.

Smout's treatment of this interesting group, the Rotalidea, is the first fundamental work since that of Carpenter in 1862. The classification presented may be difficult for many to comprehend at first glance, but no serious student of Foraminifera, whether specializing in the artifically grouped "small" or "large" Foraminifera, can well afford to neglect this important paper. It is the opinion of the reviewer that in time the major part of Smout's classification will be accepted by the specialists in the field.

ALFRED R. LOEBLICH, JR.

MESOZOIC INVERTEBRATE FAUNAS OF PERU. *Part 1. General Introduction. Part 2. Late Triassic Gastropods from Central Peru. Bull. Amer. Mus. nat. Hist., Vol. 101.*

By Otto Haas. The American Museum of Natural History, New York. $6.00. xii + 328 pp. + 1 folded map + 1 folded chart + 18 pl.; text ill. 1953.

Field work carried out by several geologists and paleontologists in central Peru has yielded rich collections of fossils now assembled in the American Museum of Natural History. Since most of the fossils from the Triassic are silicified, acid preparation of the material could be used, and has resulted in a tremendous multiplication of specimens. Thus the author had at his disposal about 16,500 individuals, by far the richest and best preserved fauna of Triassic gastropods that has ever been studied. It includes 26 families, 62 genera, and 181 species (many of them new), which are described in the present monograph in a very scrupulous manner.

Among the fossil-bearing lots of the Cerro de Pasco region in central Peru three lithologic groups, the "*Myophoria*" limestones, bituminous limestones, and light limestones, may be distinguished, and each of them is characterized by a distinct gastropod fauna. Stratigraphically they range from Norian to Rhaetian.

In the light limestones of Rhaetian age the overwhelming majority of gastropods consists of small and even very small shells. In this respect the fauna resembles the well-known faunule of St. Cassian in the southern Alps. The small shells of the light limestones are, however, intermixed with some very rare specimens which are several times as large as the average forms. They alone are to be considered as full grown, while the others are juveniles. This inference could also be corroborated statistically. The gastropods under consideration thus do not represent true dwarf faunas, and

the same holds true for the St. Cassian faunal assemblages. In both cases it may be assumed that the small juvenile shells were inhabitants of algal thickets. Of course, size-sorting agents have also played an important role.

An extensive bibliography with full utilization of the European literature concludes the voluminous and amply illustrated monograph. The author is to be congratulated heartily on this very fine and valuable piece of work.

O. H. SCHINDEWOLF

ARCHAEOPTERYX LITHOGRAPHICA. A Study based upon the British Museum specimen.

By Gavin de Beer. British Museum (Natural History), London. £2. xii + 68 pp. + 16 pl.; text ill. 1954.

In June, 1861, H. von Meyer published a note reporting that the imprint of a feather had been discovered in the Solnhofen slates—deposits of the Jurassic age in which birds were not supposed to have existed. In August, 1861, v. Meyer made known the discovery of an almost complete skeleton surrounded by feather impressions; it represented indeed the oldest of birds, *Archaeopteryx lithographica* (acquired by the British Museum, this is known as the London specimen). A complete skeleton was found in 1877 (the Berlin specimen). No further find has since been made. A monograph was published on each specimen in 1863 and 1884, respectively, and the *Archaeopteryx* bibliography covers 6½ quarto pages in the memoir here reviewed. This memoir fulfills a duty of the present generation of scientists, viz., reinvestigation with modern methods. The task has been carried out on the London specimen, painstakingly and brilliantly, by one of the foremost of biologists; and we are presented with a book of great importance far beyond the realm of paleontology.

Preparation with needles has been continued for the last 15 years, uncovering previously invisible elements. The presence of some of these bones had been disclosed by x-ray photographs. The use of spotlights with different colored filters and the taking of molds of various structures aided both investigation and illustration. The modern technique of greatest value was the use of fluorography. The fine-grained Solnhofen limestone has not only preserved as impressions, with every minute detail, the feathers without whose presence the skeleton would have been classified among the Reptilia, but Solnhofen fossils have another quality apparently unique. In ultraviolet light their organic remains show bright fluorescence. Thus bones and teeth, whose color in daylight is like that of the matrix, become clearly distinguishable from imprints and from concretions that have filled or replaced bones. Excellent photographs of the specimen and of some of its parts taken in ordinary light and in ultraviolet light demonstrate how ultraviolet photography reveals previously untraced or questionable bone, and details of bones and teeth. Fluorography has finally proved a fact suspected at various times, namely, that the London specimen does not deserve its epithet, "headless." The skull is represented by a number of scattered fragments. These include bones of the cranial vault, and their identification definitely establishes a concretion rising above the slab as part of the endocranial cast, reproducing much of the brain of *Archaeopteryx*. The only parts missing are the right foot, lower jaw, and some of the neck vertebrae.

There is much of interest for the historian of science not only in the chapters on the history of the London specimen and on previous investigations but also in the most extensive of the 9 chapters, the detailed Description of the British Museum Specimen of *Archaeopteryx* and Comparison with the Berlin Specimen (pp. 10–38). In the chapter on the affinities between the two specimens, the supposed differences on the specific or generic or even family level disappear. When account is taken of the differences in preservation, and of different individual age and possibly sex, the Berlin specimen can only be regarded as an individual about one-tenth smaller than the London specimen, and belonging to the same species. The holotype is the London specimen —not, as is commonly assumed, the first-reported, but then unnamed, feather. Sorting the mosaic of characters typical of the ancestral and typical of the evolving class, 12 features are listed in which *Archaeopteryx* was in the reptilian phase of evolution, and 4 in which it differs from any reptile and agrees with modern birds. The systematic position, about which 36 different views have been adopted, is as follows: Class Aves; Subclass Saurornithes Nicholson 1879; Order Saururae Haeckel 1866; Family Archaeopterygidae Huxley 1871; Genus *Archaeopteryx* von Meyer 1861; Species *A. lithographica* von Meyer 1861. The Triassic ancestor of *Archaeopteryx* and thus of birds will presumably be found among the little-specialized, small, running, and occasionally bipedal Thecodontia. In several respects *Archaeopteryx* is intermediate between one of these reptiles, *Euparkeria*, and pigeons. While many theories have been advanced about the origin of flight in birds, all the evidence now available favors the theory that assumes an arboreal "pro-avis." The structure of *Archaeopteryx*—as seen directly, and as it reflects soft organ systems, the feeble development of pectoral muscles and cerebellum—suggests that its mode of flight was gliding.

Describing, figuring, and comparing every part of *Archaeopteryx*, discussing and convincingly answering every related question of a general nature, this book is of the definitive memoir kind. The author notes that new facts might be revealed if the Berlin specimen were also subjected to new preparation. Moreover, other specimens may at last come to light either in the busy Solnhofen quarries or elsewhere. But new discoveries,

one feels, will increase rather than lessen the value of this outstanding contribution to the knowledge of fossils and of evolution.

T. EDINGER

NEUE ERGEBNISSE DER MENSCHLICHEN ABSTAMMUNGSLEHRE. *Ein Forschungsbericht.*

By Gerhard Heberer. Musterschmidt-Wissenschaftlicher Verlag, Göttingen. DM 7.50 (paper). ii + 86 pp. + 1 pl. + 1 folded chart; text ill. 1951.

This is a compact and very useful little summary up to and including late 1951. As a matter of fact the author is even more "up-to-date" than that, for, surprisingly enough, Piltdown does not figure in his phyletic chart at all.

The bulk of the monograph is given over to an out-and-out presentation of the basic descriptive morphology of each fossil find. As might be expected the more recent South and East African finds come in for the lion's share of attention. Heberer's descriptive analysis is bulwarked by a very thorough annotation and bibliography, given on pp. 74–85.

It is fair to say, I think, that the presentation is marked by its orthodoxy, rather than by any radically different or controversial views. In his final "family tree," going back to *Propliopithecus* of the Oligocene, he presents more of a *path* or *zone-area* of evolutionary continuity than a narrowed avenue or even line. There is evident direction and trend, to be sure, but there is no forced trunking or branching. Heberer presents his phyletic chart in what he calls a "net-structure."

In the chart the Hominoidea (Pongidae and Hominidae) are outlined. The main theme goes from *Propliopithecus* (Oligocene) to *Proconsul* (mid-Miocene); the *Dryopithecus-Sivapithecus* group are here also; to one direction goes *Pongo*, to another *Gorilla* and *Pan*. Picking up the main theme (which is divergent from the foregoing), we find the upright position achieved by late Miocene; from here to mid-late Pliocene (15 million years) there are no "links" in the chain; yet this is the time (4–600,000 generations worth!) of "hominisation." At its end we meet *Australanthropus* (*Australopithecus*) *africanus*, *A. prometheus*, and *Plesianthropus* (all Upper Pliocene); we also meet fire. Then, in early Pleistocene, we thread our way through a veritable maze of fossil forms; of these only Mauer and Steinheim are nearly linear to Cro-Magnon and *H. sapiens*. The others—*Paranthropus*, *Sinanthropus*, *Pithecanthropus*, Neanderthal, and (?) *Africanthropus*—are caught in the dragnet, but in more peripheral meshes. Taken by and large I presume that detail, including a bit of the time variable, may be challenged, but the broad sweep is fairly evident and reasonably accurate.

Heberer bases his postulates upon genetic grounds. He correctly observes that knowledge of evolutionary trait-complexes must be based not upon the study of individuals but upon breeding populations. Resultant relatively fast (breeding) or slow (isolated) gene flows will give rise to new and emergent forms. With this comes a generalized gene pool from which further progress may arise; however, there also may be, for long periods of time, "adaptive plateaus" (S. Wright) which are comparatively static. Postulates such as these may explain both irregularities (time differences) and asymmetries (form differences) in human evolution. In a stimulating arithmetic assumption the author calculates that between *Proconsul* and *Australanthropus* (15 million years) there occurred 10,000 mutations per gene locus; of these 1/100 were progressive; hence, there were 100 mutations for each genetically controlled trait. Whether or not these calculations are precisely correct is, I think, really not the point—the basic assumptions seem warranted.

All told this is a refreshing, stimulating, little handbook, both in fact and in theory.

W. M. KROGMAN

LE PROBLÈME DE LA GENÈSE DE L'HOMME.

By Max Westenhöfer; condensed and annotated by S. Frechkop. Editions de l'Office de Publicité, S. A., Bruxelles. 50 fr. (paper). 52 pp. + 4 pl.; text ill. 1953.

This small volume is a rather free abridgment of Westenhöfer's *Das Problem der Menschwerdung*. By using illustrations from the nervous and skeletal systems, Westenhöfer successfully demolishes a non-existent theory—that man is the culmination of an evolutionary series which passes sequentially through the extant anthropoid apes. Throughout he stresses the "primitivism" of man, and feels that man differs so much from all other animals that he should be placed in a class apart from the rest of the animal kingdom. Since man's features are essentially primitive, he must be older geologically as well, Westenhöfer reasons, and he expects (and hopes) that remains of *Homo sapiens* will be found some day dating from the beginning of the Tertiary. His general thesis is quite untenable in the light of our present knowledge.

FRANK C. ERK

GENETICS AND CYTOLOGY

MIKROSKOPISCHE UND CHEMISCHE ORGANISATION DER ZELLE. *2. Colloquium der Deutschen Gesellschaft für physiologische Chemie A.M. 6–7 April 1951 in Mosbach (Baden).*

Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM 9.60 (paper). ii + 102 pp.; ill. 1952.

In the last few years, the development of new tech-

niques and instruments has stimulated investigation of the microscopic and submicroscopic elements of the cell. For cytologists, physiologists and biochemists, zoologists, and bacteriologists further opportunity arose to study interrelationships of structure and function—of chemical topography of cells. The present symposium deals with these problems of localized cytomicrochemistry.

Five papers are presented (in German), each followed by a brief discussion. The topics include submicroscopic cell structure, localization of enzymes, and structure of nucleic acids and nucleoproteins. They will be of interest and importance to all biologists concerned with the chemical analysis of intracellular structure.

R. G. GRENELL

GENERAL CYTOLOGY. *Second Edition.*

By E. D. P. De Robertis, W. W. Nowinski, and Francisco A. Saez. W. B. Saunders Company, Philadelphia and London. $7.75. xiv + 456 pp.; ill. 1954.

This revised and enlarged second edition of *General Cytology* is an interesting and clearly written account of the chemical, physiological, morphological, and structural aspects of modern cytology. In this book those aspects one might reasonably call "classical cytology" are somewhat overwhelmed by the physicochemical, functional, and cytochemical considerations. For those whose interest lies in this direction, which is the modern trend of cytological research, the book is an excellent summary of the status of knowledge in these fields through the early 1950's. However, because of the present complexity of our knowledge of cell structure and function the volume necessarily may be too advanced for use in most undergraduate courses. It should, however, have useful application in advanced cytology and cell physiology courses and will be a useful general reference text for graduate students and research workers in any of the several fields the authors painstakingly attempt to integrate into their *General Cytology*.

The second edition has a number of new sections which help to give it a somewhat better overall balance than the original. These include the action of radiations and chemical agents in cytogenetics, a new section on plastids, new material on cytochemistry and ultrastructure, and a new section on cell metabolism. Even with these improvements and with the much needed increase in amount of space devoted to plant material there is still inadequate attention to certain aspects of classical cytology which should be presented in any well-balanced course in general cytology. A more apt title for the book might have been "General Cytology —With Emphasis on Ultrastructure, Cell Physiology and Cytochemistry." This would indicate clearly that major emphasis had been put on this approach to cytology.

The book is as a whole well written and well illustrated. A negligible number of errors were noted. The book will find many enthusiastic users amongst those who wish to bridge the gap between the structural and functional aspects of cells and their many complex components.

ARNOLD H. SPARROW

THE *SANICULA CRASSICAULIS* COMPLEX (UMBELLIFERAE). *A Study of Variation and Polyploidy. Univ. Calif. Pub. Bot., Vol. 27, No. 3.*

By C. Ritchie Bell. University of California Press, Berkeley and Los Angeles. $1.25 (paper). Pp. 133–218 + 5 pl.; text ill. 1954.

This complex of plants is of western distribution, and the several grades of polyploidy and interspecific hybridization found within it make the complex interesting from the point of view of floral evolution. The polymorphism of the complex stems largely from genic and environmental variations at diploid levels, with species crosses and polyploidy to at least the octoploid state blurring the distinction between legitimate species. The approach taken and the results obtained conform in general to the earlier studies of the California group on the *Crepis* and *Bromus* complexes, and the conclusions reached add little that is new to our understanding of reticulate evolution.

C. P. SWANSON

INTERNATIONAL REVIEW OF CYTOLOGY. *Volume III. Edited by G. H. Bourne and J. F. Danielli. Academic Press, New York.* $9.50. viii + 530 pp.; ill. 1954.

The present volume seems to provide a better balance between the morphological and the physiological aspects of cytology than did the two earlier ones, which were heavily weighted in favor of the physiological. One can hardly dispute such preference, however, for the shifting of cytological emphasis toward the chemical and physical and away from what might be termed the more classical biological is proceeding very rapidly. Furthermore, the relation of cytology to genetics is being more adequately covered in an older and similar series of volumes.

The articles carried in Volume III are broad in coverage, and where the reviewer can judge objectively, the material is adequately handled and controversial topics are fairly and judiciously treated. Much cytochemical and enzymological information is found scattered throughout most of the reviews. The list of topics embraced are as follows: animal cell nutrition (Waymouth), tissue culture studies (Bucher), action of urethane on mitosis (Cornman), giant chromosomes (Alfert), mammalian chromosomes (Beatty), nuclear enzymes (Dounce), enzymes and differential centrifugation (De Duve and Berthet), enzymes and em-

bryonic differentiation (T. Gustafson), azo dyes in histochemistry (Pearse), chamber culture methods (Williams), mast cells (Asboe-Hansen), elastic tissue (Dempsey and Lansing), and nerve cell composition (Brattgard and Hyden). The fact that these volumes are bringing the studies of foreign investigators to the attention of English-reading scientists offsets in a substantial manner the inadequacies of the present abstracting services, and inevitably makes them necessary tools for the active research worker.

C. P. SWANSON

COLCHICINE—*in Agriculture, Medicine, Biology, and Chemistry.*

By O. J. Eigsti and Pierre Dustin, Jr. The Iowa State College Press, Ames. $5.00. xiv + 470 pp.; ill. 1955.

Colchicine is casually accepted today by biologists as one of the standard laboratory chemicals having a highly specific action and, consequently, useful in the study of certain problems. Its action on the living cell is to interfere with the development and function of the spindle, and this action has certain attendant effects on cytokinesis. While disturbing spindle function, it has little or no effect on the chromosomes, with the result that it has become routinely and widely employed by a variety of investigators working on a variety of problems: the study and arrest of cancerous cells, the investigation of metaphase chromosomes exposed to mutagenic agents, the induction of polyploids and aneuploids in plants, etc. Such effective use of colchicine is possible, however, only because of the enormous amount of research done since 1937, when the botanists became interested in it as a means of inducing polyploids. Its use in medicine for the treatment of gout antedates the biological work by many years, and is apparently unrelated to it in so far as cellular effects are concerned.

The present volume is an exhaustive treatise on the drug itself, its action on the living cell, and its applicability in medicine, biology, and plant breeding. Material on animals as well as plants is included, together with chapters on the chemistry, pharmacology, methods of preparation, and techniques of treatment. A good deal of information on mitosis, meiosis, and polyploidy is to be found in various parts of the book, while detailed studies of spindle and chromosome behavior are reported. It is very probable that the essential information in this volume could have been contained effectively in a review paper of moderate length, but I suppose that it is always desirable to have everything done and said on a subject concentrated in a single volume. The book is appropriately dedicated to A. P. Dustin, father of the junior author, and the man who brought colchicine to the attention of biologists in 1934.

C. P. SWANSON

GENERAL AND SYSTEMATIC BOTANY

PLANT LIFE IN MALAYA.

By R. E. Holttum. Longmans, Green & Company, London, New York, and Toronto. $3.00. viii + 254 pp. + 1 pl.; text ill. 1954.

This volume is intended as a general introduction to study of plant life in Malaya. In the words of the author's preface, it is "primarily for the Malayan resident who wishes to begin a study of Malayan plants. It includes the kind of information about plants which I think should be taught in Malayan schools, and I hope it will be useful to teachers who have had no special botanical training; it should also be useful to students in their last year at school and their first year at the university." The plant life of the area is, of course, enormously diversified and complex in structure and adaptation. To do justice to it, as the author remarks, would require many more books.

The book consists, in a sense, of a series of essays in the form of chapters. The titles of these chapters give some idea of the kinds of material covered—Roots and Stems; Trees, Palms, Pandans, and Tree Ferns; Bamboo, Ginger, and Orchid; Yams and Some Other Tubers; Vegetative Propagation; Flowers and Hybrids; Fruits and Seeds; Bananas; Grasses; The Story of the Pigeon Orchid; etc. The actual content, however, of any one of these essays is quite varied, and the author has no hesitation in bringing into it ideas and materials from other fields of subject matter. When examined as a whole, the book gives a surprisingly good coverage of general botany, with its materials woven into simple and readable discussions about plants. Would that this could be achieved more generally in elementary texts. Illustrative material throughout the book is derived from common or well-known plants. Most of them are things that the average Malayan knows from their common use values, or as ornamentals, or as ubiquitous inhabitants of roadsides, farms, and dooryards.

The book is abundantly illustrated with excellent line drawings of plants. At the end there is a list of botanical equivalents of Malay and English plant names, and a general index. Although the author has designed the book primarily for use in its own region, it is readable and informative for anyone with an interest in tropical botany.

H. M. RAUP

INTRODUCTION TO BOTANY. *A Laboratory Approach to Plant Science.*

By James Marvin, Fred H. Taylor, and Louise A. Raynor. Burgess Publishing Company, Minneapolis. $2.50 (paper). iii + 119 pp.; ill. 1952.

LABORATORY MANUAL FOR GENERAL BOTANY. *Parts I and II.*

(I) By Robert W. Hoshaw, Sanford S. Tepfer, and Barbara J. Peebles; illustrations by Ruth S. Hoshaw.

(II) By Robert W. Hoshaw and Sanford S. Tepfer; illustrations by Ruth S. Hoshaw. Burgess Publishing Company, Minneapolis. $2.00 each (paper). (I) vi + 70 pp.; ill.; (II) vii + 66 pp.; ill. 1953.

GENERAL BOTANY LABORATORY MANUAL.
By John W. Hall. Burgess Publishing Company, Minneapolis. $3.50 (paper). iii + 218 pp.; ill. 1953.

WORKBOOK IN FUNDAMENTALS OF PLANT SCIENCE.
By George B. Cummins, George A. Gries, Samuel N. Postlethwait, and Forest W. Stearns. Burgess Publishing Company, Minneapolis. $3.00 (paper). iii + 136 pp.; ill. 1954.

LABORATORY MANUAL FOR GENERAL BOTANY.
By Ward L. Miller. Burgess Publishing Company, Minneapolis. $2.50 (paper). ii + 134 pp.; ill. 1953.

LABORATORY EXERCISES FOR GENERAL BOTANY.
By Herbert M. Clarke and Richard I. Evans. Burgess Publishing Company, Minneapolis. $1.50 (paper). iv + 104 pp.; ill. 1953.

INTRODUCTORY PLANT PHYSIOLOGY LABORATORY MANUAL.
By Edwin B. Kurtz, Jr. Burgess Publishing Company, Minneapolis. $2.50 (paper). v + 65 pp.; ill. 1954.

PRINCIPLES AND PRACTICE IN PLANT CYTOLOGY.
By W. S. Boyle. Burgess Publishing Company, Minneapolis. $2.59 (paper). iii + 57 pp.; ill. 1953.

A FIELD KEY TO THE COMMON NON-WOODY FLOWERING PLANTS AND FERNS OF MINNESOTA, *Based Largely Upon Vegetative Characters.*
By John B. Moyle. Burgess Publishing Company, Minneapolis. $2.00 (paper). ii + 73 pp.; ill. 1953.

The numerous manuals available for laboratory study would seem to indicate a profound change in the manner of handling both general and specialized courses in the plant sciences. This, however, is not the case, for their recent prevalence stems not from any basic alteration in the teaching of botany but from the more widespread availability of laboratory manuals which were formerly mimeographed within departmental confines, and were consequently not exposed to public examination. What strikes one as rather amazing is the almost absolute similarity of the first six manuals listed above. A slight variation in an illustration for labelling, a rearrangement of chapters, and a substitution of one species for another can be found, but on the whole the presentation, content, emphasis, and philosophy is the same as it was when the authors took their first course in botany. Is Botany so cut-and-dried that there is no place for variation, and is this the only approach that is possible? As a teacher I know full well that a subject takes on life or death from him who presents it, but the uniformity exhibited here is indicative of the doldrums in which the science is becalmed. It is little wonder that Botany has so slight an appeal to our present undergraduate student. Most of these manuals include some genetics, albeit somewhat timidly and certainly not centrally, and only one of them considers evolution—the greatest unifying principle in the biological sciences—to be a subject worthy of laboratory study (and unfortunately, this single exceptional manual confuses taxonomy and evolution). This is not to say that these manuals are not adequate for their purposes; they are all professionally correct, but oh, so dead.

The following gem, by bard unknown, epitomizes the present state of the science today, so far as elementary courses are concerned:

There should be no monotony
In studying your Botany;
  It helps to train
  And spur the brain—
Unless you haven't gotany.

It teaches you, does Botany,
To know the plants and spotany,
  And learn just why
  They live or die—
In case you plant or potany.

The remaining three manuals are presumably for somewhat more advanced students. That on plant physiology is quite elementary, that on cytology even more so, since it covers only mitosis and meiosis in diploids and meiosis in one tetraploid. This amount of cytology could be stuck in the eye of a freshman without undue pain. The field key appears to be a very well done job, and its usefulness should extend beyond the boundaries of Minnesota.

A word about the publisher who has done all of these manuals. The offset printing is very well done, and the service offered to schools in the form of inexpensive spirally bound volumes is considerable.

C. P. SWANSON

BASIC BOTANY. *An Introduction to the Science of Botany. Second Edition.*
By Fred W. Emerson. The Blakiston Company, New York and Toronto. $5.00. xiv + 426 pp. + 1 pl.; text ill. 1954.

"While the various subjects for investigation require somewhat different methods of attack, there are a few steps that are almost always taken.

"First, the problem is clearly outlined.

"Second, all possible information that has a bearing on it is assembled. To this end, the investigator both searches for all relevant discoveries that have been made by others and carries out carefully planned observations and experiments of his own. . . .

"Third, all the evidence at hand is evaluated to see if a *theory* cannot be formed that will show agreement between the various facts.

"Fourth, this theory is tested in every way possible to discover flaws."

Any introduction to a science should present a better view of scientific investigation than this one quoted from Emerson. This Baconian view of science which maintains that one gathers all the facts and then formulates theory has been examined by philosophers and historians and found wanting. See, for example, Whewell, *Novum Organon Renovatum;* DeMorgan, *A Budget of Paradoxes;* Macaulay, *Lord Bacon;* Singer, *A History of Biology;* and Morris Cohen, *Bacon and the Inductive Method.* Nor has the Baconian method been followed by the most productive scientists. A review of the work of Darwin, Pasteur, or any of the leading physical scientists will bear this out. Outstanding present-day biologists also speak strongly against the Baconian view. See the brief statements in Simpson's *The Meaning of Evolution,* and in Dubos' *Louis Pasteur, Free Lance of Science.* In addition to the quotation above, the Baconian misconception of science shows its influence at several other places in Emerson's book: see the kind of question asked on p. 23; the method of discussing van Helmont's experiment (p. 34); the statement (p. 163) that "The scientist in his search for truths depends . . . on such evidences as he can find—all of them—and draws his conclusions on the basis of these findings"; the second paragraph under Chemistry and Kinship (p. 174); and the discussion of the mechanisms of evolution (p. 175).

No discussion of the theoretical framework of biology, within which botany is located, is presented in this book. Nor is there a general discussion on the characteristics of good theory and the place of theory in science. The cell theory is not treated as such, and thus a good opportunity for teaching method in science is missed. These subjects have been touched upon in previous reviews (*Q.R.B.*, 26: 56, 1951; 29: 144 and 162, 1954). so will not be specifically treated here.

Since most of the criticisms up to this point can be applied to nearly every textbook in biology, including botany and zoology, they must not be permitted to weigh too heavily against an individual book. It is certainly possible that my own emphasis upon theory is over-extended, but if this be so the condition derives from a constant study of the history of science with major emphasis on Darwin and Pasteur. Darwin said: "How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service." And Pasteur: "Preconceived ideas are like searchlights which illumine the path of the experimenter and serve him as a guide to interrogate nature." Since the major views, or preconceived ideas, worked on by these two men were the theory of evolution and the theory of biogenesis, two of the four major theories in biology, would it not be wise to forget the notions of Bacon and follow the methods of two of the greatest biologists?

The sequence of topics in Emerson's book follows largely the usual pattern, but, unlike some, evolution is discussed prior to the chapters on the major groups of plants. This sequence is very desirable because it permits theory to operate here as it should: to simplify and unify various independent classes of facts. Even though one may wish to criticize adversely some things in the chapter on evolution, the excellent use of the theory in later discussions of the major groups of plants calls forth the highest praise. The concept of evolution weaves through these 9 chapters and knits the subject matter together in a most exemplary way.

Possibly part of the author's success here is because he uses what he calls the "Newer Classification." Eleven main divisions are used in place of the older four. A table (p. 185) compares the two systems in such a way that there is no doubt as to what the new groups cover. The trend by writers of elementary botany books to use, and even in some cases to develop, a better arrangement of major groups is most commendable, and we can expect that, even if they err a little, they will perform good service by stimulating research to test the relationships implied by their arrangements.

In the chapters on the structures and functions of the higher green plants, these subjects are very well developed. The descriptions of structure are clear, and related functions are brought in efficiently. Specific examples might have helped on pp. 96 and 135. These two places stand out because in dozens of other places in the book examples have been used so effectively. A bad slip is the statement that plants grow upward partly because they are negatively geotropic. One should not confuse the name of a phenomenon with its cause.

In chapter 5 the two original diagrams—one on energy transfer and the other on the nitrogen cycle—are especially good. After devising such a neat diagram to use under the heading of "the flow of energy," it would have been better to leave "cycles of energy" out of the chapter's title, since in reality there is no cycle in the sense that we use the word for nitrogen, carbon, and others.

No figure numbers or table numbers have been used in this book, and consequently a few errors in references to figures are present that might have been avoided. The attempt to tie the figures closely to the text has on the whole been successfully carried out. Too many of the photographs are gray or fuzzy for a second edition. The line drawings are all good to excellent. The book's size and 2-column page should make it convenient for the student to use. Each chapter starts with a brief outline and ends with supplementary readings.

At the end of the book is a list of important references over 2 pages long, a glossary, and the index. The reference list is good but should have included Singer's *History of Biology.* Radl's book on *The History of Biological Theories* is of doubtful value. The Harvard Case Histories on biological subjects should by all

means be included in such lists. The glossary appears to be very good; the index, only fair.

RALPH W. LEWIS

PROCEEDINGS OF THE SEVENTH INTERNATIONAL BOTANICAL CONGRESS, STOCKHOLM, JULY 12–20, 1950.

Edited for the Executive Committee by Hugo Osvald and Ewert Åberg. Almqvist & Wiksell, Stockholm; [The Chronica Botanica Company, Waltham.] $17.35. 900 pp. + 20 pl. 1953.

It is virtually impossible to review adequately a volume so weighty and so diversified in content; it can only be said that it is in printed form and generally available to the botanical world. In its 899 pages are included statements as to the inception and organization of the congress, the principal addresses by Wahlen, Sirks, Verdoorn, Went, Goodspeed, Turrill, Darlington, and Vouk, descriptions of the excursions taken, papers and discussions presented at the various sectional groups, and various miscellaneous speeches. The volume represents an excellent cross-section of activity in the botanical world, and as such becomes an important historical document as well as a current summary of research in progress.

C. P. SWANSON

THE USTILAGINALES OF THE WORLD. *Contribution No. 176, Dept. of Botany.*

By George Lorenzo Zundel. The Pennsylvania State College School of Agriculture, State College, Pa. $3.50 (paper). xii + 410 pp. 1953.

Certain similarities between the present work and L. O. Overholts' *The Polyporaceae of the United States, Alaska, and Canada* (1953) may be noted. Both are monographic treatments of particular groups of fungi, based in each case on a lifetime of study of the group; both are posthumously published works; and both are the result of work done at the same institution.

The present volume, together with G. W. Fischer's *Manual of the North American Smut Fungi* (1953), should serve as monographic treatments of the Ustilaginales, on a worldwide basis, for many years. Following a brief introduction, which deals primarily with the history of the smuts, their taxonomy and economic importance, the body of the work is devoted to detailed descriptions and collection records of the various species. The usual division of the order into two families, Ustilaginaceae and Tilletiaceae, is retained. Some 1200 species are considered, this number being somewhat larger than usually given in mycology texts. In the Ustilaginaceae, 18 genera are recognized; of these only *Cintractia* (68 spp.), *Sorosporium* (105), *Sphacelotheca* (130), *Thecaphora* (31), *Tolyposporium* (31), and *Ustilago* (330) contain a large number of species, while six genera are monotypic. Similarly, in the Tilletiaceae, only *Doassansia* (35 spp.), *Entyloma* (170), *Tilletia* (96), and *Urocystis* (114) are sizeable among the twelve genera recognized in this family. A host index occupies 60 pages of the text.

There is at present a serious dichotomy among workers with this group as to whether the concept of species should be based primarily upon the morphology of the parasite, or upon host specificity. Dr. Zundel belongs to the former school of thought. One might have expected, therefore, that keys to the species of each genus would have been included. In their absence, the host index must necessarily serve as the first line of attack by any user of the manual.

F. T. WOLF

DISPERSAL IN FUNGI.

By G. T. Ingold. Clarendon Press, Oxford; Oxford University Press, New York. $2.90. viii + 198 pp. + 8 pl.; text ill. 1953.

The number of spores produced by certain fungi can only be called astronomical. For example, a single specimen of the giant puff-ball is estimated to contain 7 trillion spores, and we are told that there may be 10 trillion uredospores on an acre of slightly rusted wheat. The manner in which fungus spores are liberated, and the means by which they are subsequently dispersed, whether by air currents, insects, larger animals, or water, represent problems which have occupied the attention of the author for a number of years, and which form the subject matter of this small volume. Following a brief introduction, something over one third of the book is devoted to spore liberation, which is sometimes purely passive, but which in many fungi is an active process of violent discharge. This is accomplished by a variety of mechanisms, of which a series of illustrative examples are given. A reader with a philosophical turn of mind cannot fail to be impressed by the way in which a common problem has been neatly solved in a variety of ways by the different organisms, the solution "chosen" by a given organism apparently being the one most likely to result in a maximal chance of its own survival under the particular set of conditions in which it exists in nature.

Successive chapters deal with spore dispersal by wind, by insects, by larger animals, and by water. Discussion of the dispersal of fungus spores through the agency of wind is centered upon plant pathogens such as the cereal rusts, though the observation is made that the vast majority of all fungi are anemophilous. The chapter on dispersal by insects considers particularly the stinkhorns, ergot of rye, the pycniospores of rusts, and the Dutch elm disease. Dispersal by larger animals is illustrated by such diverse examples as the passive dispersal of coprophilous fungi by herbivores, the

dispersal of truffles by rodents, and of chestnut blight by birds. The point is made that *Homo sapiens* must be held responsible for the intercontinental spread of a number of serious plant pathogens to areas in which they did not originally occur. Water is involved in the dispersal of the bird's nest fungi, the aquatic Phycomycetes, and a variety of Ascomycetes and Hyphomycetes of terrestrial ancestry, which have reverted to an aquatic habitat. Perhaps the ultimate in adaptation for dispersal is attained by fungi which are seed-borne, thus depending on their hosts for dispersal, though it is pointed out that the principal groups of obligate parasites are not usually of this type.

The book is written in a readable style, is exceptionally free of typographical errors, and is well illustrated by 8 plates and 90 text figures.

F. T. Wolf

The Ferns and Fern Allies of New Mexico. *Univ. N. Mex. Pub. Biol., No. 6.*

By Howard J. Dittmer, Edward F. Castetter, and Ora M. Clark; drawings by Jeanne R. Janish. The University of New Mexico Press, Albuquerque. $1.00 (paper). 140 pp.; ill. 1954.

As suggested in the preface to this little book, many who have thought of New Mexico primarily as a hot and dry country will be surprised at the number of ferns to be found there. Most of the species are in the more massive wooded mountain ranges. However, there are numerous kinds that are able to thrive in desert situations. This manual lists 7 families, 24 genera, and 75 species and varieties of ferns and fern allies. However, 11 of the species have not actually been collected in the state though they have been found in similar country in neighboring states and are to be expected in New Mexico. Six species previously reported for New Mexico are excluded.

In the main body of the work, following brief notes on the position of the Pteridophyta in the plant kingdom, their general characteristics, and their fossil occurrence in New Mexico, there are complete keys to families, genera, and species. Also there are both genera and species descriptions, with information on habitat and general distribution. The essential nomenclatorial synonymy is also included for each species. The book is profusely illustrated with line drawings which include habit sketches and details of critical characters. The book closes with a rather full glossary, and an index to both common and Latin names.

H. M. Raup

The Polyporaceae of the United States, Alaska and Canada.

By Lee Oras Overholts; prepared for publication by Josiah L. Lowe. University of Michigan Press, Ann Arbor; Geoffrey Cumberlege, Oxford University Press, London. $7.50. xiv + 466 pp. + 133 pl. 1953.

Students of American polypores probably consult Murrill's keys in *North American Flora* (1907–08) or the more recent ones of Lowe more frequently than any other sources in making identifications. The present volume, based upon a lifetime of study of this group, had been substantially completed by L. O. Overholts at the time of his death in 1946, and forms a welcome addition to the monographic treatments of the bracket fungi. Following a brief introduction in which previous work on the taxonomy of the group is reviewed, the bulk of the work is devoted to keys, descriptions, and illustrations of species. The treatment does not include *Boletus* and related forms, or *Fistulina*, which Overholts would exclude from the family, nor does it include *Merulius* or *Poria*, *Merulius* having been satisfactorily dealt with by Burt (1917), while the species of *Poria* are still in a largely chaotic state despite intensive study by Baxter, Lowe, and others.

The taxonomic philosophy of the author can only be termed conservative; Overholts was neither a describer of "new" species nor an erector of "new" genera. Eight genera are dealt with in the work: *Fomes*, with 40 species and 3 varieties; *Lenzites*, with 5 species; *Daedalea*, with 7; *Trametes*, with 13; *Favolus*, with 6; *Polyporus*, with 162 species and 8 varieties; and *Cyclomyces* and *Hexagona*, both of which are monotypic. Overholts does not recognize genera such as *Ganoderma* and *Polystictus*, with the result that *Polyporus* becomes a very large assemblage, the key to which occupies no less than 44 pages of the text.

The treatment of each species consists of synonymy, habitat, distribution, references to illustrations, and miscellaneous notes. In the author's own words, "long lists of synonyms that might have been copied from the literature, and so have given the manual a more learned appearance, have been omitted." Likewise, the data presented concerning host range and distribution are based almost entirely on specimens actually examined by the author. The illustrations, consisting of 675 photographs arranged in 124 plates, are especially noteworthy. Eight additional plates deal with microscopic characters. There is also a bibliography, a glossary, and an index.

While the treatment of *Polyporus* may come under criticism, the illustrations will prove extremely helpful to the user of the manual, and it is certain that the book represents a major and much-needed contribution to the study of a large, prominent, and economically important group of fungi.

F. T. Wolf

The Ferns and Fern Allies of Minnesota.

By Rolla M. Tryon, Jr.; illustrated by Wilmâ Monserud. University of Minnesota Press, Minneapolis.

$4.00 (cloth); $2.75 (paper). xx + 166 pp.; ill. 1954.

The introduction to this book contains a brief account of the general geography of the state of Minnesota, and a few notes on the distribution of ferns in the state. There are also suggestions for amateurs and others who wish to cultivate ferns, collect them and form a herbarium, or find others of similar interests with whom they may associate.

Following a key to the families, there are keys to genera, general generic descriptions, and keys to species. Under each species there is a diagnostic description, notes on habitat and general distribution, and a spot map showing the known distribution in Minnesota. The maps are based primarily upon herbarium material at the University of Minnesota. The entire work is profusely illustrated with line drawings of taxonomically significant characters, and silhouettes of the principal species to show the form of the fronds. The book closes with a comprehensive index.

The book was prepared while R. M. Tryon was a member of the staff of the University of Minnesota, and was to some extent inspired by the late Prof. F. K. Butters. It supersedes the *Guide to the Ferns and Fern Allies of Minnesota*, by Rosendahl and Butters, which was published in 1909 and is long since out of print. The book is of handy size and well printed, and should prove useful to taxonomists as well as to amateur botanists.

H. M. RAUP

PLANT MORPHOLOGY

CONTRIBUTIONS TO THE MORPHOLOGY OF THE DELESSERIACEAE. *Univ. Calif. Pub. Bot., Vol. 27, No. 5.*

By Florence Signaigo Wagner. University of California Press, Berkeley and Los Angeles. $1.00 (paper). Pp. 279–346; ill. 1954.

This item is concerned with the morphology of a group of marine algae, and the utilization of this knowledge for taxonomic clarification. It constitutes a Ph.D. thesis done under the direction of Papenfuss, and as such follows along the line of studies carried on by him and his students.

C. P. SWANSON

FIBER MICROSCOPY. *A Textbook and Laboratory Manual.*

By A. N. J. Heyn. Interscience Publishers, New York and London. $5.50. xiv + 408 pp. + 12 pl.; text ill. 1954.

The textile industry has long used the tools and methods of the microscopist for the solution of problems involving both natural and synthetic fibers. The importance of such studies has long been recognized, and the role of the investigator in a highly competitive field looms increasingly large, yet most fiber technologists have entered the field, as it were, through the back door. The present volume, being both a textbook and a laboratory manual, should assist in the sound training of students in fiber microscopy, there being no other similar volume available. Topics which are included involve the various fibers with their morphological and physico-chemical characteristics, methods of identification, staining and sectioning, and a reasonably thorough treatment of microscopy from the point of view of theory, limitations, and application. References are given to more detailed and advanced studies. The volume is designed for a one-semester course of approximately 3 months in length, and the balance between theory and practice is judiciously handled. It should be of considerable value from a technological standpoint.

C. P. SWANSON

THE HIDDEN LIFE OF FLOWERS.

Translated from the French text of J. M. Guilcher; photographs by R. H. Noailles. The Philosophical Library, New York. $4.75. 94 pp.; ill. 1954.

Botanists are accustomed to line drawings as a conventional way of illustrating floral structure, and simplicity and economy usually dictate that this type of illustration be used in most textbooks. That the structure, life, and even purpose of a flower can be adequately and accurately revealed by photography is amply demonstrated in this modest volume. Arranged in sequence and given unity by brief, ably handled descriptions, these photographs trace the flower from bud to mature seed. A variety of species, both wind-pollinated and insect-pollinated, is used, but an initial sequence of photographs of the corn-poppy sets the stage and provides a point of departure for the infinite expression of structure and pollinating devices found among the flowering plants. The cost and somewhat limited scope of this book may prevent its widespread sale, but there can be no doubt that an extraordinarily high standard of illustration has been achieved.

C. P. SWANSON

PLANT PHYSIOLOGY

ALGAL CULTURE *from Laboratory to Pilot Plant. Carnegie Inst. Wash. Pub. 600.*

Edited by John S. Burlew. Carnegie Institution o Washington, Washington. $1.75 (cloth); $1.25 (paper). x + 358 pp.; ill. 1953.

One of the research projects of the Carnegie Institution has been the study of photosynthesis. Part of this study was concerned with the mass culturing of algae

and a study of their chemical composition. As a result of these studies the proposal was made that the green alga *Chlorella* be mass-cultured for food or fuel use. This problem was turned over to several organizations, among them the Stanford Research Institute and, later, Arthur D. Little, Inc., for pilot plant development. The present publication contains the reports of pilot plant experiments as well as the laboratory reports of investigations at the Carnegie Institution. Experiments on the mass culturing of algae have also been carried out in a number of foreign countries, particularly Japan. Reports on these developments are included in the book.

Many of the investigations here reported are published for the first time. There is a wealth of valuable information on the fundamental aspects of the growth of algae as well as more practical information. There are data on the nutritional value of algae as well as detailed chemical analysis. Detailed directions are given for growing algae, and it is possible that the algae may turn out to be ideal organisms for studying many problems in plant physiology.

G. R. NOGGLE

ANNUAL REVIEW OF PLANT PHYSIOLOGY. *Volume 4. Edited by Daniel L. Arnon and Leonard Machlis. Annual Reviews, Stanford.* $6.00. vi + 453 pp. 1953.

Like its predecessors in this series, the 4th annual review is an interesting and useful volume. Although parts of some chapters are repetitious, a wide variety of problems in plant physiology and biochemistry is considered.

J. G. Wood, in the first chapter, presents an imaginative discussion of both inorganic and organic nitrogen metabolism in plants. His views and those of his Australian colleagues are for the most part quite stimulating, even though several theories advanced have since been disproved.

Among selected topics which Brown and Frenkel discuss in their review of photosynthesis are the source of photosynthetic oxygen, the enzymology of photosynthesis, and, of course, the quantum requirements of photosynthesis. Although the discussions are thoughtful, it is somewhat bewildering to find this same chapter in the 1953 *Annual Review of Biochemistry*.

Recent studies of organic acids in plant metabolism are expertly reviewed by Burris. The oxidation and interconversion of organic acids, their isolation and analyses, and their role in carbohydrate, fat, and nitrogen metabolism are discussed.

Hill and Hartre provide an outstanding chapter on plant hematins such as the cytochromes, root nodule hemoglobin, catalase, and peroxidase. A summary of evidence for the cytochrome system as a major terminal oxidase in plants is presented along with an excellent critical evaluation of inhibitor studies in determining the nature of terminal oxidases. Their discussions of anion respiration, adaptation of cytochromes in yeast, and the function of root hemoglobins are also very interesting. A similar but more diffuse discussion of respiratory inhibitors is given by W. O. James. His review includes an extensive list of various enzyme inhibitors.

Various phases of auxin physiology are treated in 2 chapters of this volume. Veldestra presents a critical analysis of both old and new work on the relation of structure to activity of growth-promoting and inhibiting substances. His eminence in this field assures an authoritative discussion. The second chapter, by Crafts, is more concerned with practical application of various hormones, although several sections loosely titled "mechanisms of auxin action" are included.

The physiology of fruit and root growth is covered in chapters by Nitsch and Burstrom respectively. In each instance, a multitude of fascinating physiological problems encountered in studies of these organs is highlighted. Also included in this volume are reviews by Went on temperature effects, Melin on mychorrizal relationships, and Virgin on physical properties of protoplasm. Haagen-Smit discusses the biogenesis of terpenes. Bergmann, in his review on plant sterols, gives a classification based on optical rotation and a list of sterol distribution. The properties and methods of analysis of fluorescent compounds found in plants are also provided in a review by Goodwin.

The range of topics discussed in this 4th volume and the general excellence of presentation makes this book an outstanding contribution to plant physiology literature.

MILTON ZUCKER

VEGETABLE FATS AND OILS. *Amer. Chem. Soc. Monogr. Ser. 123.*

By E. W. Eckey; with a chapter by Lawrence P. Miller. Reinhold Publishing Corporation, New York. $16.50. x + 836 pp.; ill. 1954.

This volume was written in response to demands for a comprehensive and up to date coverage of the vegetable fats and oils, which were the subject of an earlier ACS monograph by G. S. Jamison.

While the fats are vitally important in animal and human nutrition, the non-food uses of fats and oils have also long engaged the attention of chemists. This volume, therefore, should find widespread acceptance since it is literally crammed with information concerning this important group of compounds.

Approximately one-third of the volume is devoted to the fundamentals of fat chemistry, including chemical composition, physical properties, chemical properties, and biochemical and nutritional aspects of fats. The remainder of the book is devoted to descriptions of the

fats and oils prepared from a number of botanical sources.

R. VAN REEN

PLANT PHYSIOLOGY.

By Jacob Levitt. Prentice-Hall, New York. $5.00. viii + 172 pp.; ill. 1954.

Plant Physiology, by Jacob Levitt, is so brief as to be hardly believable—a total of 156 pages of text printed in large type. Fully half of this constitutes a general introduction and a section on Plant Biophysics and Biophysical Chemistry. In view of the small size of the book, it is not surprising that a very large number of topics usually considered to be of interest in plant physiology get little more than a listing by name. For instance, after a general chapter on concepts of metabolism, and a chapter each for respiration and photosynthesis, the rest of plant metabolism, including all areas of nitrogen metabolism from nitrate reduction to protein metabolism, all polysaccharides (other than starch), lignins, lipids, alkaloids, nucleic acids, pigments, etc., is contained in 3½ pages. Likewise, all of growth and development—including cell growth, growth rates, dormancy and rest periods of seeds, buds, etc., all growth movements, auxins, organic nutrition of excised organs, photoperiodism, thermoperiodism, and vernalization is crowded into 27 brief pages.

In spite of the handicap of such limited space, Levitt has done a really excellent job of organization on the selected topics. This is especially true in the first major section of the book, on Biophysical Chemistry. Here a major theme is in evidence, viz., the explanation of certain plant activities directly in terms of known physical mechanisms. The physical principles are presented first, and then their applications and complications in the living system are clearly indicated. Although this part of the book could easily be expanded to twice its present size without loss of coherence or with confusion of the basic principles, it is still much more adequate than the succeeding sections. Also well organized and clear, and not vitally deficient in content, is the chapter outlining the general principles of metabolism. The rest of the book, in my own opinion, does not contain enough material to constitute an adequate introduction to the basic, elementary principles of plant physiology.

In one other respect, the book can be highly recommended. This is its balanced and sensible treatment of the controversial subjects that arise. This is especially true for the pathway of transport of nutrients, and the mechanism of phloem transport. In general, Levitt does not at any point hesitate to say that only a tentative conclusion is acceptable as yet, and that evidence still exists for several points of view about the mechanism of a particular process.

Levitt's *Plant Physiology* will probably not be useful as a textbook in its present form. Perhaps the most serious drawback is that the vast majority of the material is simply stated, without any description. Students in an elementary course will probably be unable to get an adequate picture of most of the processes or phenomena from this presentation, let alone an idea of the experiments which led to the dicta. Most of the book might qualify as a balanced and well-written outline, to be read quickly the night before a final examination. If ever it were expanded to the size of a full textbook, while maintaining its present good features, it would probably be an outstanding book in the field.

A. T. JAGENDORF

ECONOMIC BOTANY

VEGETABLE PRODUCTION *with Special References to Western Crops.*

By John H. MacGillivray. The Blakiston Company, New York and Toronto. $5.00. viii + 398 pp.; ill. 1953.

Vegetable Production with Special References to Western Crops, by John H. MacGillivray of the University of California, is a book that had its origin in mimeographed form for use in a beginning course in vegetable production.

The first half of the volume deals with general production principles. MacGillivray classifies vegetables on a temperature tolerance basis as well as on a botanical basis. He breaks Cool Season Crops into three groups, all of which prefer 60–65° F. temperatures but which have different tolerances for freezing weather. The Warm Season Crops he separates into two rather artificial groups.

A brief discussion of the economic importance of vegetables is given, indicating the comparative value of the vegetables produced in the eleven western states as compared with total United States production. The crops grown in the various areas of the western states are also given.

In keeping with the level of training of the expected reader, the author briefly discusses general concepts of soils for vegetable production, physiological factors affecting vegetable production, vegetable improvement through plant breeding, importance of good seed, and seeding practices. One of the problems discussed, while not exclusively western, is the damage caused by smog. More than a half million dollars of damage to farm crops in the Los Angeles area has been attributed to smog. The use of pelletted seed, a relatively new development, obviates field thinning, reduces the incidence of such diseases as mosaic in tomatoes, and facilitates planting of small seeded crops. The author presents an excellent discussion on the use of commercial fertilizers, manure and organic matter, indicating the advantages and disadvantages of each.

Chapters on preservation, grades and grading, and food value are well done and are supported by United States and California standards for the various vegetables. Nutritional charts and tables present data on the relative rank of vegetables based on nutrients per pound, per acre, and per man hour of production time. Insect and disease control comes in for brief treatment in a separate chapter, although a more detailed discussion of specific diseases affecting specific crops is presented in subsequent chapters.

The second half of the book deals with detailed information on all aspects of cultural practices. The vegetables are placed in their 5 groups based on thermoclassification. The crops of major importance in each group are discussed separately and mention is made of some of the characteristics of the minor crops in each group. MacGillivray discusses the following subjects under each major crop: botany, origin and history, producing areas, food value, varieties, soil, fertilizer, planting and spacing, irrigation, cultivation, harvesting, storage, quality characteristics, insects and diseases.

The book is well written and well illustrated. It should serve as an excellent textbook for students in a beginning vegetable crops course, particularly in the western United States.

C. E. MINARIK

YEAST TECHNOLOGY.

By John White. John Wiley & Sons, New York. $8.00. xvi + 432 pp. + 15 pl. + 1 folded chart; text ill. 1954.

The outstanding feature of this book is its treatment of yeast physiology, nutrition, biochemistry, and genetics from the viewpoint of the yeast technologist in industry rather than from a general academic point of view. Since there are not too many up-to-date books devoted solely to the yeasts, White's volume is welcomed as filling a definite gap in the mycological (and industrial) literature.

The book is concerned with the industrial handling of yeast, either as a primary product (as for baking) or as a secondary product (as in brewing). The major part of the material covers the manufacture of compressed yeast for use in baking, with chapter titles such as: Yeast Physiology and Nutrition, The Growth of Yeast and the Mechanism of Yeast Growth, Modern Practice in Production of Baker's Yeast, Control of the Assimilation and Harvesting of the Yeast Crop, The Effect of Aeration and other Factors upon Yeast Growth and Fermentation, and Influence of Temperature on Yeast Growth and Fermentation. Perhaps the most worth-while feature is the presentation of methods of calculation of yields, efficiency of fermentation, growth rates, feeding rates, etc., from a practical and yet fundamental point of view.

The manuscript is remarkably free of errors, although the Backman laboratory dough mixer is incorrectly ascribed to "Backmann" (p. 220). It is difficult to understand why in some of the references the initials of the authors are given whereas in others they are omitted. However, these are very minor matters, since all in all the book has a definite place both in the industrial yeast laboratory, as a bench and reference book, and in the academic laboratory, as a source book of information on industrial processes and problems.

SEYMOUR POMPER

AN INTRODUCTION TO INDUSTRIAL MYCOLOGY. *Fourth Edition.*

By George Smith; foreword by Harold Raistrick. Edward Arnold, London; [St. Martin's Press, New York]. $6.00. xiv + 378 pp.; ill. 1954.

Since the third edition of this book has been adequately reviewed by F. K. Sparrow (*Q. R. B.*, 21: 382, 1946), this review will emphasize the differences between the latest and the earlier edition. The fourth edition is larger by 100 pages. The etymology of the names of fungi and technical terms are included for the first time, two new chapters on nomenclature and microscopy have been added, and the number of photomicrographs has been increased from 143 to 161. Old chapters have been supplemented, revised, or rewritten in the light of more recent findings. The book is intended for individuals with little or no training in botany who may be confronted with problems concerned with molds of industrial use or with spoilage of industrial materials, and it meets this purpose admirably.

The author considers "that the Fungi do not belong to either of the Plant and Animal Kingdoms, but constitute a third co-equal Kingdom." In my own opinion, this proposition is at least as well founded as are certain so-called "modern" schemes of classification appearing in recent elementary botany textbooks, in which the plant kingdom is divided into numerous phyla, the majority of which consist of organisms hitherto regarded as algae. The point of view is possibly somewhat extreme in both instances.

The first 3 chapters are entitled Introduction, General Morphology and Classification, and Nomenclature, respectively. A section of 7 chapters deals in detail with molds apt to be met with in industry: Zygomycetes, Ascomycetes, Yeasts, Fungi Imperfecti, and Hyphomycetales, entire chapters being devoted to the important genera *Aspergillus* and *Penicillium*. The influence of Thom and Raper's book on *Aspergillus* and that of Raper and Thom on *Penicillium* is easily discernible in these chapters. Additional chapters deal with laboratory equipment and technique, the physiology of mold fungi, maintenance of culture collections, control of mold growth, industrial uses of

fungi, and mycological literature. The average reader might have a right to expect a somewhat fuller treatment of the control of mold growth and industrial uses of fungi, but in general the balance is good and the selection of material has been judicious. The present edition has an appendix on microscopy which is new. Numerous, excellent photomicrographs illustrate the book.

There are a few misstatements of fact. *Saprolegnia* is erroneously mentioned as a parasite of insects (p. 16). The smuts, the Entomophthorales, and the Exoascales are not obligate parasites, contrary to statements appearing on pp. 19, 31, and 50, respectively, nor are the Exoascales included among the Plectomycetes in most schemes of classification. *Sporotrichum schenckii*, although a human pathogen, is not a dermatophyte (p. 129). In several instances, the author uses the word infection to refer to inanimate materials, when contamination would be preferable. These inaccuracies are minor, and could easily be rectified in subsequent printings.

F. T. Wolf

Advances in Agronomy. *Volume VI. Prepared under the Auspices of the American Society of Agronomy.*

Edited by A. G. Norman; advisory board, J. E. Adams, G. H. Ahlgren, G. W. Burton, J. E. Gieseking, I. J. Johnson, Randall Jones, R. Q. Parks, and R. W. Simonson. Academic Press, New York. $8.00. xii + 384 pp.; ill. 1954.

The current volume follows the same approach as previous issues in this series. Progress in basic research in crop and soil science is reviewed in the light of agronomic practices. Nine articles are presented, covering the topics of crop improvement, plant nutrition, crop management and adaptation, soil water, and international collaboration in agriculture.

Problems in technical aid for the improvement of agricultural practices in undeveloped countries are explained by Harrar. Recent developments in sorghum improvement and progress in the production of hybrid sorghum are reviewed by Quinby and Martin. Culbertson has coordinated reviews on advances made in flax production since 1936, covering the aspects of seed storage, diseases, the production of resistant and better varieties, and weed control. Trace elements are discussed by Nikitin with respect to processing in forms suitable for agriculture and their use in foliage and soil treatment and in mixtures with major fertilizers. Lawton and Cook have reviewed the work on the potassium nutrition of plants as influenced by soil and climatic factors, on the effect of potassium deficiency in field and fruit crops, and on potassium requirements of crops. Kelley has discussed water requirements of crops, consumptive use in plant growth, total use of water on the farm, availability of water as related to root habits and to moisture stress in soil, and has also presented the conflicting views on soil moisture availability. McIlvain and Savage have reviewed the great changes that have been brought about in range improvement as a result of the application of basic agronomic principles to range problems. Recent trends in the management of corn-belt soils involving the use of cultural practices like the stubble mulch system are discussed by Melsted. These include sod seedbeds and special type equipment in conjunction with high applications of commercial nitrogen. Wilsie and Shaw have discussed the adaptation of crops to environment and the influences of climatic factors on problems of crop production.

As in previous volumes, the subjects are presented authoritatively and thoroughly. This is an excellent reference work for any one interested in either the technical or applied aspects of agronomy.

Gilbert H. Ahlgren & N. A. K. Rao

Garden Friends and Foes. *A Practical and Informative Book for the Home Gardener, Dealing with the Birds, Animals, Insects, Weeds, and Plant Diseases that Confront Him.*

By Richard Headstrom; illustrated by the author. Ives Washburn, New York. $3.50. xiv + 220 pp.; ill. 1954.

The home gardener is often confronted with a bewildering array of strange animals and plants whose presence he is never certain whether to welcome or to lament. If they are welcome he may not know how to encourage them and, more frequently, if they are not desirable, he may not know how to eliminate them. This book provides the information to resolve some of these difficulties. Other books on similar topics are available to gardeners, but this one is all-inclusive, for it treats of friend and foe alike and covers both plants and animals. Birds, mammals, reptiles, amphibians, arthropods, molluscs, and even nematodes are treated in the animal section; weeds, smuts, fungi, and viruses in the plant section. Methods of attracting desirable organisms are suggested; methods of discouraging or destroying the undesirable are described. The latter methods include the use of frightening devices, traps, baits, sprays, and other effective remedies. Although this book is intended for the average gardener, it is assumed that that individual is already acquainted with the plants and animals by name. More and better illustrations to help identification, or at least references to publications where these organisms might be looked up, would have enhanced the value of this book. An index in a work of this sort is certainly essential and should have been provided.

Henri C. Seibert

FRUITS, VEGETABLES AND FLOWERS. *Physiology and Structure in Relation to Economic Use and Market Quality.*

By George M. Kessler. Burgess Publishing Company, Minneapolis. $2.00 (paper; spiral bound). iv + 68 pp.; ill. 1954.

This is a paper-bound volume intended primarily as a supplementary textbook for students majoring in institutional management of one sort or another and who will presumably be engaged in the handling of these products in the trade. Little knowledge of biology is necessary to understand the contents, which deal specifically with the relationship of plant physiology and structure to market quality. Although the book is well written, it is exceedingly difficult to understand how any college student requires a textbook so elementary that it could be digested by a high school freshman in a single perusal.

C. P. SWANSON

SWEET CORN.

By Walter A. Huelsen. Interscience Publishers, New York and London. $10.50. xv + 409 pp. 1954.

Sweet corn, of course, does not have the economic importance in agriculture that field corn does, yet it is nevertheless a vegetable which is typically American. This book attempts, and succeeds reasonably well, to cover the history of sweet corn in its many phases. Much of the volume is taken up with the processing of this product by canning or freezing, but ample space is given to historical aspects as well as to the growing, breeding, genetics, and taxonomy of maize. It cannot supplant, for the breeder, the numerous technical articles on sweet corn, but it should prove to be a valuable reference book to those who are particularly interested in economic botany and crop breeding in general.

C. P. SWANSON

GROWING TOBACCO IN CONNECTICUT. *Conn. Agric. Exp. Sta. Bull. 564.*

By P. J. Anderson. The Connecticut Agricultural Experiment Station, New Haven. Free upon request (paper). 110 pp.; ill. 1953.

Tobacco-growing in the Connecticut Valley owes its prominence to the cigar, and the well-being of the industry is very closely tied to the popularity of this product. During the 1900's the industry grew in importance, and except for depression periods it suffered no decline until the popularity of cigarette smoking made its inroads. It is unlikely that tobacco-growing in this state will fall below a certain level, however, for it owes its stability to the fact that the soils and climate of Connecticut produce the finest of binder and wrapper tobaccos. These appear likely to be in constant demand.

This bulletin is written for the tobacco grower. As such, it deals primarily with methods of culture and processing, as well as with recommended procedures for insect and disease control. It is, in addition, an interesting history of a crop whose culture in Connecticut goes back to about 1640. Strangely enough, the Indians grew tobacco in this region, yet there is no overlap in cultural methods between those of the Indian and those of the white man who followed so closely behind him.

C. P. SWANSON

THE PRACTICE OF SILVICULTURE. *Sixth Edition.*

By Ralph C. Hawley and David M. Smith. John Wiley & Sons, New York; Chapman & Hall, London. $7.50. viii + 526 pp.; ill. 1954.

The first edition of this popular textbook was published in 1921, and was subsequently revised in 1928, 1934, 1937, and 1946 (*Q.R.B.*, 23: 355. 1948). The current revision is the most comprehensive to date, the text having been completely rewritten and greatly expanded. Except for minor rearrangements of subject matter, however, the same general pattern of treatment is used as in the fifth edition. Expansion of the book has come about chiefly because of the substantial increase in the amount of attention devoted to the biological basis and economic objectives underlying the principles of silviculture and their application. Especially noteworthy is the fact that "genetic considerations" are not ignored. The number of illustrations in the book has been increased, chiefly by the addition of halftones of excellent quality, and which demonstrate the results of applying various cutting methods in actual practice. The excellent lists of references following each chapter and the comprehensive index will doubtless be welcomed by the current generation of students using this textbook.

SCOTT S. PAULEY

THE IMPROVED NUT TREES OF NORTH AMERICA AND HOW TO GROW THEM.

By Clarence A. Reed and John Davidson; illustrations by John Davidson. The Devin-Adair Company, New York. $6.00. xxviii + 404 pp. + 16 pl.; text ill. 1954.

This is a book that will prove of special introductory interest to the farmer or other landowner who contemplates the planting of nut trees as a commercial enterprise or hobby. The principal edible nut producers native to North America (walnuts, hickories, chestnuts, and filberts), along with their introduced relatives, and hybrids involving the indigenous and introduced

species, receive primary attention. Although the book's title suggests that only the *improved* nut trees of North America are under consideration, the beeches, oaks, and buckeyes are discussed, in spite of the fact that improvement efforts have never been undertaken with them, and that their use as food, even as mast, is negligible in this country. Introduced "nut tree" species valued for their food (pistachio, cashew, macadamia, and almond) or oil (tung) are included, and even, oddly, the ginkgo. Most of the chapters conclude with a list of references for suggested collateral reading which will be found especially useful to the potential nut grower. The final sections of the book cover the propagation and culture of nut trees, the development and filling of nuts, causes of damage to trees, and the food and chemical values of nuts. The book is illustrated with 22 halftones and 14 line drawings, all of good quality.

SCOTT S. PAULEY

PLANT REGULATORS IN AGRICULTURE.
Edited by H. B. Tukey; contributors, H. B. Tukey, C. L. Hamner, A. G. Norman, V. T. Stoutemyer, S. H. Wittwer, L. C. Luckwill, F. T. Addicott, L. P. Batjer, W. S. Stewart, Ora Smith, S. L. Emsweller, R. F. Carlson, J. E. Moulton, C. J. Willard, J. van Overbeek, K. C. Barrons, and A. E. Mitchell. John Wiley & Sons, New York; Chapman & Hall, London. $5.50. x + 270 pp.; ill. 1954.

This book consists of 16 short chapters, each 10 to 20 pages in length, and written severally by authorities in the field of plant growth regulators. Many of the chapters begin with a very elementary introduction to that particular phase of the subject and cover the latest uses of these highly important chemicals. However, most of the references cited are to papers published during the late 1940's, and the most recent references are dated 1952.

The volume is written primarily for the county agricultural agent, although the editor expresses the hope that advanced high-school students, as well as people from business and the professional world, may find it useful and interesting. The book is not intended to be a handbook of recommended practices but should provide background information on this subject of ever-increasing importance in modern agriculture.

The introductory chapter, by the editor, sets the stage by providing a brief history of the development of plant hormones, and concludes with the report of the Committee on Nomenclature of Chemical Plant Regulators of the American Society of Plant Physiologists.

The chapter on Principles of Plant Growth and How Plant Regulators Act (C. L. Hamner and H. B. Tukey), devotes 10 pages to elementary botany, well illustrated with schematic drawings of plant structure. A. G. Norman discusses The Chemical Nature of Plant Regulators in his usual lucid style, starting with the premise that the reader is unfamiliar with organic chemistry. He covers the field quite well and goes into the structure of herbicides, defoliants, sprout inhibitors, and other chemicals that affect plant physiological processes. The chapter on encouragement of roots (V. T. Stoutemyer) delves into the theory as well as the commercial practice of rooting cuttings. S. H. Wittwer reviews the progress made in controlling flowering and fruit setting in a creditable manner.

L. C. Luckwill, of the Long Ashton Research Station, Bristol, England, discusses parthenocarpy and fruit development. All but 7 of his 20 references are to U. S. publications, a fact indicating the preponderance of American work in this area of endeavor as compared with the European effort. F. T. Addicott reports on the subject of abscission and its converse, the prevention of abscission. He devotes 10 pages to an excellent presentation of the anatomy, histology, and physiology of abscission and 6 pages to the practical applications of plant regulators for controlling this process.

Methods of preventing preharvest fruit drop, of delaying foliation and blossoming, and of thinning blossoms and young fruits are treated by L. P. Batjer, who briefly surveys the results obtained with plant regulators in the field of horticulture. W. S. Stewart reviews the subject of the maturity and ripening of fruits and vegetables as influenced by plant regulators. He includes 7 pages of tables that indicate at a glance the results of various treatments upon this physiological process. The table could be improved and rendered more useful if it included references to the investigators' original reports. Ora Smith's 10-page chapter on the inhibition of sprouting constitutes a fairly thorough treatment of that subject. Naturally most of the attention here is directed toward root crops, but some mention is made of inhibiting the germinating seeds of annual crop plants and of retarding turf growth with maleic hydrazide. The latter two items appear to be out of place in this chapter.

The use of regulators in plant breeding is briefly discussed by S. L. Emsweller in an 8-page chapter. The primary use made of regulators in breeding is to increase fruit set in instances where cross- or self-incompatibilities are involved.

Four chapters and 57 pages are devoted to weed control. R. F. Carlson and J. E. Moulton discuss Weed Control in Lawn, Garden, Orchard and Nursery; C. J. Willard, Weed Control in Field Crops; J. Van Overbeek, Weed Control in the Tropics; and K. C. Barrons, Vegetation Control on Non-Crop Land. In general, the reviews are quite satisfactory for the intended audience, and the authors are to be commended for being able to treat their respective subjects so well in the relatively few pages allotted to them.

A. E. Mitchell presents an excellent review of the equipment and methods for the application of regu-

lators. He provides useful information and data on spray systems, flow rates, and dosages as affected by ground speed of spray rig, liquid pressure, etc. Conversion tables are also included.

The book as a whole presents a bird's-eye view of the place of plant regulators in agriculture. It is not recommended for the research investigator because of the elementary nature of the presentation in many of the chapters and the superficial treatment that certain phases of the subject have been accorded. It is primarily intended to provide the county agent with a background in this highly important field, and it accomplishes that purpose in an extremely satisfactory manner.

C. E. MINARIK

GENERAL AND SYSTEMATIC ZOOLOGY

A THOUSAND GEESE.

By Peter Scott and James Fisher. Houghton Mifflin Company, Boston. $4.00. 240 pp. + 17 pl.; text ill. 1954.

The pink-footed goose, a subspecific relative to the bean-goose, breeds in Greenland, Spitsbergen, and the hinterlands of Iceland. The latter site is not too well known, not having been discovered until 1929. Even though the nesting grounds of the barnacle goose and Ross' goose were not discovered until later, nevertheless more is known about them than about the main breeding grounds of the pink-foot. In 1951, Scott, Fisher, Phil (who became Mrs. Scott), and Finnur Gudtmundsson, the Icelandic naturalist, set out on an expedition to increase our knowledge of this species. Their goal was successfully achieved. They were successful not only in locating nest sites, but they also learned much about the home life of the birds; they succeeded in banding over 1000 geese and were able to reconstruct and duplicate the ancient methods of catching geese of the former inhabitants of central Iceland.

The final success was in their being able to describe the expedition, the scenery, the birds, and the day to day chores in the field in a dramatic, vivid, and yet entertainingly informal prose. Scott and Fisher each contribute chapters, a technique that enables the reader to gain individual interpretations of sights and sounds as they traveled up the Pjorsa to the Fjordungssandur, Oddkelsver, Arnarfellsver, and other tongue-twisting localities. The names may startle and frighten at first, but halfway through the book these areas become enchantingly familiar. By using the many maps that are available, the reader can see what and where these places are. Many illustrations portray the camplife, the members of the party, the scenery, and, of course, the geese. There are six appendices: the first two describe the history and status of the pink-foot in Spitsbergen and Greenland; the third is a summary of birds observed in the Psorsarver vid Hofsjökul, site of the base camp; the fourth is a list of plants found in the same area; the fifth estimates the goose population (13,000) and the methods used to arrive at this estimate; and the sixth is a bibliography. The index is divided into three main categories: birds, places, people. In summation, it can be stated that this is a thoroughly enjoyable blend of travel, adventure, birds, and science.

HENRI C. SEIBERT

DISTRIBUTION OF THE FORAMINIFERA IN THE NORTHEASTERN GULF OF MEXICO. *Bull. Mus. comp. Zool., Vol. 111, No. 10.*

By Frances L. Parker. Museum of Comparative Zoölogy, Harvard College, Cambridge. $2.75 (paper). Pp. 453–588 + 13 pl.; text ill. 1954.

The area studied in this report extends from the Mississippi River to Cedar Keys, Florida, and southward from Cedar Keys, excluding the continental shelf but extending westward from a depth of 100 m. in a series of traverses south to the Dry Tortugas. Emphasis is placed on the establishment of criteria for recognition of various environments. Death assemblages of both planktonic and benthonic Foraminifera have been studied for the area as well as living assemblages for much of the area. Six depth facies based on benthonic species have been established, each with a characteristic assemblage as follows: 12 m.—80–100 m.; 80–100 m.—130–150 m.; 130–150 m.—180–220 m.; 180–220 m.—350–600 m.; 350–600 m.—900–1000 m.; 900–1000 m.—?. In facies 1, 2, 3, and 4 there are marked lateral changes in the faunas, especially in the shallower depths. When the depth of 1000 m. is attained, faunas are fairly uniform throughout the area studied.

Twenty-two planktonic species and 205 benthonic species (including one new genus, *Stetsonia*, and ten new species) are utilized in compiling the data in the report. Miss Parker states that these constitute only a part of the fauna but a large proportion of the total population. Species not considered are present in small quantities and for the most part are considered to be without distributional significance. Species of thirteen generic and in some cases family groups are lumped together in the counts made for the several traverses. Reasons for this are given as poor preservation of material in some cases, lack of material for proper analysis, insufficient material to make a study of the various species not readily differentiated in counting, various species not sufficiently common to be considered separately, and the impossibility of identifying juvenile forms.

One series of tables shows generalized distributions of benthonic Foraminifera by depth and another series of detailed tables gives the percentage distribution of benthonic Foraminifera by traverses. Distribution of

planktonic Foraminifera is covered in two tables, one for traverse VII giving percentage distribution, and a second giving distribution of living, planktonic Foraminifera in traverses VII–XI, in numbers of specimens. Living benthonic Foraminifera are plotted on four tables in numbers of specimens for the eleven traverses.

The species discussed and described in this report are illustrated by retouched photographs, reproduced on 13 half-tone plates. All types and figured specimens are deposited in the U. S. National Museum.

Based on the admitted reconnaissance sampling in this large area, Miss Parker has produced a volume of immense interest in the study of the Gulf of Mexico, and this excellent contribution is a welcome supplement to the 1951 publication by F. B. Phleger and F. L. Parker on *Ecology of Foraminifera, Northwest Gulf of Mexico*, Geol. Soc. Amer. Mem. 46.

ALFRED R. LOEBLICH, JR.

AMPHIBIANS AND REPTILES OF WESTERN NORTH AMERICA.

By Robert C. Stebbins; illustrated by the author. McGraw-Hill Book Company, New York, Toronto, and London. $8.50. xxii + 528 pp.; ill. 1954.

This is such an excellent and balanced treatment of the reptiles and amphibians of our western states that it is difficult to decide which feature of the book is most outstanding. The illustrations, mostly line drawings, were done by the author, and accurately portray not only the individual forms discussed in the text but also illustrate the specific characters utilized in the identification keys. There is also an interesting series of distribution maps of the Ben Day stipple type which are considerably more than a compilation of existing literature records. Many of the maps show evidences of intelligent interpretation of previous work by others.

The text covers the salamanders, frogs, toads, turtles, lizards and snakes, form by form. The accounts are mainly by species, with the races being given subordinate review. There are also more general accounts of the genera, families, and orders. The ordinal and class discussions actually comprise an interesting and concise biology of the amphibians and reptiles. There is a short glossary and an index which includes primarily nomenclatorial entries.

The evaluation of this book as outstanding must be qualified with the statement that Stebbins is also the author of a recent and even more extensive *Amphibians of Western North America* and is presently working on *Reptiles of Western North America*.

There is little to criticize in Stebbins' present work. I think the descriptions of the species are perhaps a little more detailed than necessary. I would have preferred to have a reference to the page on which illustrations occur listed with each species account. Discussions in the text occasionally make reference to a particular figure or plate without mentioning the page it is on, even though the two may be 25 pages apart.

The book is mildly marred by apparent attempts at economy by the publisher. For example, identification keys are sometimes set in place as a unit, independent of their best position in the text. Economy may also explain why the tops of a number of the plates of snakes are to the left instead of to the top of the page.

It is perhaps instructive to compare this book with the same author's previous *Amphibians of Western North America*, which was published by a university press. I believe the book design was better in his earlier volume. *Amphibians* is a little easier to use than *Amphibians and Reptiles*. The books are about the same size, and the earlier book is a dollar less in cost. The *Amphibians* has a number of color plates which the *Amphibians and Reptiles* lacks, though many of the black and white illustrations are common to the two books. I do not mean this comparison to reflect unfavorably on either publisher. Actually, both are to be warmly congratulated for bringing out such valuable books.

There has never before been such an informative and well organized compendium of the herpetology of the western states. Accurate identification of the species encountered is now relatively easy. Here also is access to critical summaries of the live histories of most of the species. *The Amphibians and Reptiles of Western North America* will certainly be a standard handbook for many years to come.

ARNOLD B. GROBMAN

ZOOLOGY.

By Clarence J. Goodnight and Marie L. Goodnight. The C. V. Mosby Company, St. Louis. $6.50. 370 pp.; ill. 1954.

Another new textbook for general zoology courses has now been offered by the Goodnights, a book that incorporates "newer ideas and concepts without sacrificing basic anatomy, classification, or phylogeny . . . and which is not so large that it will frighten the timid freshman." The general treatment is to first describe a vertebrate, *Homo*, and to follow with the parade of the Animal Kingdom. I am in accord with this method from a pedagogical viewpoint. The first half of the book is therefore concerned with the various systems of the body, and concludes with chapters on cells, embryology, and genetics. The very first chapter is an introduction to the scientific method, and the second describes briefly the physical and chemical basis of life, at the same time defining atoms, ions, acids, and other terms that an ever-increasing proportion of freshmen have never heard of. The third chapter discusses classification, but to my mind it would have been better placed

just preceding or combined with the chapter on evolution. The fourth chapter describes the anatomy of the frog, a seemingly unnecessary intrusion. From this point on everything flows smoothly. The context has been well selected, being very up to date and accurate. I like the historical background brought in right with the material rather than separated into a distinct chapter. The chapters on the animal phyla are unusually complete and reflect the work of competent field zoologists. Two final chapters on phylogeny and ecology act as a cohesive conclusion to the survey of the phyla. There is a glossary, a list of references for additional reading, and a good index. The entire book is clearly written. I would rank this new entry among the better of recent outputs, and I would recommend that it be given serious consideration by anyone attempting to select a new textbook.

HENRI C. SEIBERT

LABORATORY STUDIES IN ELEMENTARY ZOOLOGY. *Second Edition.*

By Nellie M. Bilstad, Lemuel A. Fraser, and Harold R. Wolf. Wm. C. Brown Company, Dubuque. $2.00 (paper). iv + 84 pp.; ill. 1954.

LABORATORY MANUAL FOR ELEMENTARY ZOOLOGY.

By Joseph G. Baier, Jr., Merlin L. Hayes, Eldon D. Warner, Helen J. Kittsley, and Ludwig K. Pauly. Burgess Publishing Company, Minneapolis. $2.75 (paper). ix + 148 pp.; ill. 1953.

These two laboratory guides are roughly similar. Both use the frog as the basic laboratory animal, and both frequently make comparisons with corresponding mammalian structures. Both require drawings to be labeled. The *Manual* is longer because it requires questions to be answered and because it goes into more detail, has more material on physiology, provides check-lists of materials needed, and includes suggested lecture and laboratory schedules. The method of presentation is essentially the classical sequence with but slight individual modifications. Drawings, instructions, and accuracy of material seem well in order. Anyone interested in a one-semester beginning course in zoology, with emphasis on the anatomy and physiology of the frog as laboratory work, should look into either or both of these guides.

HENRI C. SEIBERT

PROTOZOOLOGY. *Fourth Edition.*

By Richard R. Kudo. Charles C Thomas, Springfield, Ill. $10.75. xi + 966 pp.; ill. 1954.

The fourth edition of this well-known book follows the same lines as the preceding editions, devoting itself mainly to taxonomy and identification. It is, in fact, essentially a manual for the identification of genera The scheme of classification adopted is conservative, following the plan extant among protozoologists of the United States, without mention of some more recent ideas presented in large foreign treatises. This fourth edition is nearly 200 pages larger than the third edition (*Q.R.B.*, 21: 190. 1946), but most of the additional space is occupied by the insertion of genera and species not considered in previous editions. The discussions of general topics that make up the beginning section of the book have been slightly expanded here and there. One notes additional material on the structure of flagella, cilia, and trichocysts based on electron-microscope studies, new material on mitosis with special reference to Cleveland's work on hypermastigote flagellates, and some discussion of the genetic work on *Paramecium*, emanating from Sonneborn's laboratory. The large body of recent work on the neurofibrillar system ("kinety" system of French workers) receives, however, insufficient attention. In general, the book retains its usefulness as an introduction to protozoology and as a guide for the initial stages of identification of Protozoa.

L. H. HYMAN

AFRICAN INSECT LIFE.

By S. H. Skaife; with illustrations by the author. Longmans, Green & Company, London, Cape Town, and New York. $11.00. viii + 388 pp. + 75 pl.; text ill. 1954.

As Skaife tells us, he has written this large and attractive book "mainly for the amateur student of natural history, for the farmer, gardener and householder who wish to know something about the numerous insect friends and foes they see about them." With this end in mind, he presents a lucidly written, non-technical review of the general appearance, life histories, and occupations of the commoner South African insects of the principal orders. Seventy plates of photographs, largely of posed insects and often retouched, 5 color plates, 3 of which are devoted to Lepidoptera, and 190 text figures—all the work of the author—well illustrate the insects with which the book is chiefly concerned. Regrettably, there is no bibliography or citation of original literature.

There can be no doubt that the South African will find this a welcome handbook to the commonest insects about him, and it will serve to point up the natural history problems deserving his attention. For the naturalists of other lands, who look for informative and engaging accounts of Africa's entomological mysteries and delights, it must prove a disappointment, but through no special fault of Dr. Skaife. In temperate lands, it seems, the insects commonly about us, those annoying to the person, destructive of crops, or of stored things, lumber, and so on, tend to a deadening sameness. Of the more than 300 insects mentioned by

specific name in the text, fully 20 per cent are cosmopolites, or nearly so. It is hard lines indeed to be presented with *Periplaneta americana*, *Plodia interpunctella*, *Eristalis tenax*, *Anthrenus verbasci*, and *Iridomyrmex humilis*, among others, when thirsting for detailed and intimate accounts of Africa's own. Unfortunately few peculiar forms are dealt with at any length, and in relatively scant instances are the discussions of endemic African insects likely to add notably to the average entomologist's fund of information. Chief among these few are the accounts of the natural history of *Amitermes*, long a subject of Skaife's special attentions, a brief comment on biting lice as taxonomists of dassies, and description and illustration of the remarkable polymorphism of the mocker swallowtail. The economic entomologist will no doubt find the book useful by its indication of how well his problem insects have fared in their invasion of South Africa.

KENNETH W. COOPER

A REVIEW OF THE *AEDES SCUTELLARIS* SUBGROUP WITH A STUDY OF VARIATION IN *AEDES PSEUDOSCUTELLARIS* (THEOBALD) (DIPTERA: CULICIDAE). *Brit. Mus. (Nat. Hist.), Entom., Vol. 3, No. 10.*

By Elizabeth N. Marks. The British Museum (Natural History), London. 18s. (paper). Pp. 347–414 + 2 pl.; text ill. 1954.

The *Aedes scutellaris* subgroup of mosquitoes consists of 18 described and 3 undescribed forms from the islands of the southern and western areas of the Pacific and from northern Australia. Mark's review of the taxonomic status of the member species is a careful blending of her own studies and the investigations of others. A key to the adult mosquitoes, augmented by detailed descriptions and clear illustrations, makes it a valuable reference. Special features which enhance the report are a map of the known geographical distribution of the members of the complex and a novel pictorial chart showing the geographical distribution of the principal taxonomic characters.

In view of the growing interest in the genetic relations of mosquito complexes, Marks has reviewed the literature on cross-breeding experiments with this group and has summarized her own experiments on the morphological changes produced in adult *Aedes pseudoscutellaris* by varied environmental conditions. Unfortunately several pertinent papers have appeared in American journals while this report was in press. However, their appearance does not reduce the value of this review.

LEO JACHOWSKI

FISHES OF THE GULF OF MAINE. *First Revision. Fish. Bull. 74, Vol. 53.*

By Henry B. Bigelow and William C. Schroeder. Fish and Wildlife Service, U. S. Department of the Interior, Washington. $4.25. viii + 577 pp.; ill. 1953.

Somehow, the able authors of the first two monumental volumes of the *Fishes of the Western North Atlantic* have found time and diligence to revise extensively the *Fishes of the Gulf of Maine*, first published in 1925 under the authorship of Bigelow and Welsh. Along with the *Fishes of Chesapeake Bay* (by Hildebrand and Schroeder, 1928) this treatise has been the chief compilation of published and original data on the fishes of the Atlantic coast of North America. So far as known, for each species of the region, these works treat the characters, habits, life history, general range, local distribution, and economic importance. *Fishes of the Gulf of Maine*, especially as now revised, is an extraordinarily full compilation of available information on the fishes that occur in the Gulf within the 150-fathom line. For this reason it is a reference book of high value. Only here and there, generally in minor details, has the "last word" been missed. There is, unfortunately, no generalized discussion of the fauna.

CARL L. HUBBS

WESTERN ATLANTIC SCORPIONFISHES. *Smithson. Misc. Coll., Vol. 121, No. 8. (Pub. 4106).*

By Isaac Ginsburg. The Smithsonian Institution, Washington. $1.10 (paper). 103 pp.; ill. 1953.

Ichthyologists count on critical treatment and original outlook in the systematic revisions by Ginsburg and on these scores will not be disappointed in this treatise. According to his custom, he has tackled boldly a group that has more or less baffled previous workers, and has again contributed significantly to systematic ichthyology. In this review the more important taxonomic characters are critically discussed and defined. A modified nomenclature of the cephalic spines is proposed. A significant observation is the early transformation, in the Haemulidae as well as in the Scorpaenidae, of the third anal ray from a terminally segmented soft-ray into a typical spine. Considerable data on meristic variation is included. Two sets of allopatric subspecies, in part extralimital, are recognized on the basis of their degree of differentiation. Otherwise the study has been strictly regional and suffers somewhat thereby. The treatment of regional differentiation in the rosefish (*Sebastes*) illustrates this point.

CARL L. HUBBS

FISHES FOUND IN THE FRESHWATERS OF TEXAS.

By Frank T. Knapp. Ragland Studio and Litho Printing Company, Brunswick, Ga. $2.00 (paper). viii + 166 pp.; ill. 1953.

This treatment of the freshwater fishes of Texas is patterned after Hubbs and Lagler's *Fishes of the Great Lakes Region* in that it begins with remarks on keys and classification, briefly treats the general distribution of the fauna, outlines methods of study, states technical terms, gives a semipictorial key to orders and families, limits general discussion on the habits and economics of species to the group headings, provides brief keys to species, includes only ranges in the species lists, and illustrates most of the forms. In considerable part the general fauna discussion is in accord with known facts. Because the fauna is complex and poorly known it is small wonder that one not particularly proficient in the technical aspects of systematic ichthyology should have erred frequently in treating the nomenclature, characters, and distribution of species. Some of the errors in statements of range have been noted by Clark Hubbs (*Tex. J. Sci.*, 1954: 277–291). The rather crude outline figures are moderately adequate for the more unique types, but will be of limited help to either novice or expert in the difficult, speciose groups, particularly the minnows and the darters. Diagrams of diagnostic features enhance the usefulness of the book. The typography and diction are marred by innumerable, largely minor errors, inconsistencies, and inelegancies. Nevertheless, the book should prove of considerable use, and contains some new information.

CARL L. HUBBS

A COLORED ATLAS OF SOME VERTEBRATES FROM CEYLON. *Volume I. Fishes. Ceylon National Museums Publication.*

By P. E. P. Deraniyagala; illustrated by the author. The Ceylon Government Press, Ceylon. Deluxe Edition Rs. 30/-; Ordinary Edition Rs. 15/-. xii + 146 pp. + 34 pl.; text ill. 1952.

Lavishly and generally well illustrated with 34 colored plates and many figures, by the author, this volume treats in detail all the freshwater fishes of Ceylon, and briefly deals with selected marine fishes of the families that are represented by colored plates (a type of coverage more common in the Orient than in the Western world). The fossil fishes are also listed and figured. A page of zoogeography indicates the separation of Ceylon from India about the beginning of the Miocene, allowing for major differentiations, followed by several unions, and with a final separation, probably 5,000 years ago, that has led to subspecific differentiation. Two cichlids in India and Ceylon are said to indicate an African affinity, and more definite affinities with the Malayan area are claimed. This is a valuable compilation, with some original material, all handsomely presented.

CARL L. HUBBS

A COLORED ATLAS OF SOME VERTEBRATES FROM CEYLON. *Volume Two. Tetrapod Reptilia.*

By P. E. P. Deraniyagala; illustrated by the author. Ceylon National Museums Publications, The Ceylon Government Press, Colombo. Rs. 15/-(Ceylon Currency); $3.15 (paper). xii + 102 + iv pp. + 46 pl.; text ill. 1953.

The second volume of *A Colored Atlas of Some Vertebrates from Ceylon* is devoted to the reptiles of the island. Its horizontal format, 31 x 24 cm., is governed by the size of the colored plates. Within the compass of its 35 colored plates, 11 black and white plates, 44 text figures, and 159 pages (of which only 113 are numbered) the work includes a miscellany of information about the turtles and crocodiles and lizards of Ceylon, the snakes being reserved for another volume of the series.

The information thus made available about this segment of the fauna of Ceylon is in itself valid and of interest. The juxtapositions, as within any unorganized miscellany, are likely to be startling. Matters of an elementary nature and of popular interest are associated with technical details, of certain items only, concerning anatomy and embryology. Common names are given in English, Sinhala, and Tamil. The author has not been able to resist the tendency to split the families of sea turtles and lizards into subfamilies, to an extent that I personally do not regard as significant or useful.

Unquestionably the most notable segment of the book is its series of colored illustrations, which include 8 turtles, 1 crocodile, and 26 lizards. The colors are bold and brilliant, mostly without accessory groundwork or tree branch; in some the scales are not drawn in, a technique which always produces an unsatisfactory representation of a scaled animal. On the meritorious side, they are undoubtedly the best representations of these creatures available, often the only ones, and they reflect Deraniyagala's acquaintance with them in life. Their value to the naturalist who wishes to gain a general idea of the life of Ceylon is unquestioned.

Within the text, every herpetologist should index the information as to the anatomy and embryology of turtles, and more especially the sections under each species (in all groups) devoted to food, behavior, and reproduction. The text supplements the plates by giving keys to all of the Ceylon species and subspecies of turtles (8 species), crocodiles (2 species), and lizards (57 species). It is a great satisfaction to have the classification of the Ceylonese reptiles so thoroughly established that it can be made the framework for the record of Deraniyagala's great accumulation of ecological information.

KARL P. SCHMIDT

THE BIRDS OF THE BELGIAN CONGO. *Part 4. Bull. Amer. Mus. nat. Hist., Vol. 75B.*

By James P. Chapin. American Museum of Natural

History, New York. $10.00 (paper). x + 846 pp.; ill. 1954.

With this impressive volume J. P. Chapin's monumental work has reached completion, no less than 22 years after the appearance of the First Part. During this period it has become indispensable to all persons who concern themselves with the bird world of Africa. The more one seeks counsel and information from it, so much the more one learns to prize it. The author has had to consider no less than 1,077 bird species and to bring together everything that has become known in respect to their distribution, geographical variation, and modes of life in the Belgian Congo and in Ruanda-Urundi, and in his discussions he has often far transcended the limits of this region. This final volume is devoted to the families of the Dicruridae, Laniidae, Prionopidae, Paridae, Certhiidae, Oriolidae, Corvidae, Sturnidae, Zosteropidae, Nectariniidae, Ploceidae, and Fringillidae. There is appended a Gazetteer of African Localities mentioned in Parts 1 to 4, no less than 100 pages in length, wherein all the localities (approximately 4,000) mentioned in the 4 volumes appear with their geographical coordinates in alphabetical arrangement—a very valuable aid to every zoologist who has to do with the African sources of the present literature. The conclusion is provided by a Bibliography for Parts 1 to 4 (pp. 739–809) and the Index of the scientific names in Part 4. Thanks to Chapin's ceaseless energy and sure judgment, the ornithologist can now inform himself far more exactly and without effort as to the birds of Central Africa than in regard to the birds of East and South Africa.

E. Stresemann

Bird Recognition. *I. Sea-Birds and Waders. New and Revised Edition.*

By James Fisher; illustrated by Fish-Hawk; maps, mainly compiled by W. B. Alexander, and charts compiled by the writer. Penguin Books, Melbourne, London, and Baltimore. 85 cents (paper). 190 pp.; ill. 1954.

Bird Recognition. *II. Birds of Prey and Water-Fowl.*

By James Fisher; illustrated by Fish-Hawk; maps compiled by W. B. Alexander, and charts compiled by the writer. Penguin Books, Harmondsworth (Middlesex) and Baltimore. 85 cents (paper). 182 pp.; ill. 1951.

This series of pocket books on bird recognition will undoubtedly become very popular and successful in the British Isles. It attempts to combine bird identification and bird biology. This amount of information would make any one book too unwieldy for field work or too expensive for many pockets; therefore it will ultimately be published in 4 volumes. The first, entitled Sea-Birds and Waders, contains the Procellariiformes (petrels), Pelecaniformes (cormorants), and Charadriiformes (gulls, sandpipers, auks). The second includes the Strigiformes (owls), Falconiformes (hawks), Ciconiiformes (herons), Anseriformes (ducks), Gaviiformes (divers), and Colymbiformes (grebes). Two other projected numbers will cover the game birds and larger perching birds (vol. 3) and the smaller perching birds (Vol. 4). It is to be noted that the usual check-list sequence is considerably altered for purposes of convenience. For each species there are usually three topics discussed in the text: recognition, breeding, and distribution. Each bird is illustrated by a black-and-white drawing, a map of the British Isles shows its breeding range and relative abundance, and a unique chart plots the yearly cycle of the bird's activities. Useful references to additional information on the species are included whenever such exist. In the front of each book there is a field key, and in the back there are additional illustrations of birds in flight and in winter plumage, comparisons of similar-looking species, silhouettes, and other visual aids to recognition. As the saying goes, these books are packed with information, and this is one time when the favorite cliché of reviewers is literally true.

Henri C. Seibert

A History of Birds.

By James Fisher. Houghton Mifflin Company, Boston. $3.75. 206 pp. 1954.

James Fisher, one of England's leading ornithologists and active in many fields as a research worker, prolific writer, traveler, scientific editor, and a regular broadcaster on the radio, knows how to think clearly and how a book on a generalized subject should be written but so often is not. The present one, which should be required reading for all students of ornithology and would-be authors, presents in a relatively short space a history of ornithology and bird systematics. This is followed by chapters on geographical distribution, evolution, and the dynamics of bird populations. The study of the latter is the author's favorite field of research, and one in which he plays a leading role. The only important subjects not covered deal with migration, habits, and ecology, but these are to be presented in a second volume. This first volume is fully annotated and supplied with an important but not ponderous bibliography. Fisher has most skillfully distilled a vast amount of information, and has presented it in a manner readily understood and made alive by pithy comments and interpretations. It is to be hoped that this book will be read by many.

Charles Vaurie

THE MAMMALS OF THE HUACHUCA MOUNTAINS, SOUTHEASTERN ARIZONA. *Ill. biol. Monog., Vol. XXIV, No. 1.*

By Donald F. Hoffmeister and Woodrow W. Goodpaster. The University of Illinois Press, Urbana. $4.00 (cloth); $3.00 (paper). vi + 152 pp.; ill. 1954.

The Huachuca Mountains are an isolated range lying in the Gadsden Purchase tract of Arizona near the Mexican border. They are entirely surrounded by desert, but the mountains themselves rise through the Upper Sonoran and Transition life zones, and the tallest peaks enter the Canadian zone. The lowest reaches of the mountain proper are the aprons of alluvium that spread out fanwise from the mouths of canyons. The vegetation differs somewhat from the adjoining desert, but is a part of the Lower Sonoran Zone.

The greater part of the book is devoted to a synoptic list of the mammals of the area. Each species is listed with its principal synonyms, together with records of occurrence, and in many cases comparisons with closely related subspecies. Of particular interest are the concluding remarks, which frequently contain considerable information on ecology and life history. Notable contributions are made to the knowledge of the desert shrew, *Notiosorex crawfordi*, the long-tongued bat, *Choeronycteris mexicana*, and the long-nosed bat *Leptonycteris nivalis*.

The Huachuca mountains are a meeting place of northern, southern, and eastern forms. 78 species and subspecies are found there, in 56 of which the mountains do not form the distributional boundary. The remaining 22 find the limit of their range there. Thirteen are southern or subtropical forms which reach their northern limit in the Huachucas. Five eastern and 4 northern forms also extend into but not beyond these mountains.

BRYAN P. GLASS

MAMMALS OF CALIFORNIA AND ITS COASTAL WATERS.

By Lloyd Glenn Ingles. Stanford University Press, Stanford. $6.00. xiv + 396 pp.; ill. 1954.

In revising and enlarging his former work on the *Mammals of California*, Lloyd Ingles has produced a book that will attract the general public as well as serve the needs of professionals. The species are identified in pictorial keys, done in excellent half-tone, in the style originated by Roger T. Peterson in his Field Guide series on birds. These should be exceptionally useful in identifying living animals in the field. Many excellent photographs are also used, and the range of each species is depicted on a map of the state. Not all species are discussed in detail, but each type of mammal is treated as to its habits, economic importance, etc. Identification features are provided opposite the pictorial keys.

Additional features are a survey of the Mammalia, past and present; a discussion of the various habitat types of California, with their plant indicators; an illustrated Appendix on the preparation of study skins; a chart of dental formulae; an artificial generic key to skulls; and an illustrated section on the identification of scats. Besides providing an up-to-date checklist for the technician and professional, this book should do much to promote "mammal-watching" as a popular pastime among California naturalists.

BRYAN P. GLASS

LIST OF LAND MAMMALS OF NEW GUINEA, CELEBES AND ADJACENT ISLANDS 1758–1952.

By Eleanor M. O. Laurie and J. E. Hill. British Museum (Natural History), London. £1. 10s. ii + 176 pp. + 3 pl. 1954.

This checklist of the mammals of the New Guinea-Celebes area is the latest in the excellent series of Old World lists published by the British Museum (Natural History). This work will be of inestimable value to mammalogists who are studying the fauna of a region which is certainly one of the most complex, fascinating, and least known in the world.

Sufficient study material is now available and has been reported on to allow a considerable amount of generic revision. Out of the welter of named forms the authors have made good progress in establishing groups with biological reality. Three hundred and fifty-one species are recognized. A new genus, *Mayermys*, has been set up to describe another addition to the unusual rodents that have been discovered in New Guinea. This small murid is peculiar in that only one minute molar tooth is present on each side of the upper and lower jaws.

Laurie and Hill have given us a scholarly work which may well stand as a model for authors of similar checklists. They always evidence a common-sense approach to the basic problems involved. The work of future revisers has been made easier by the generous use of references that have been carefully checked against the original publications, and by the thoughtful plan of the entire book.

HOBART M. VAN DEUSEN

ECONOMIC ZOOLOGY

COMMON OCEAN FISHES OF THE CALIFORNIA COAST. *Fish. Bull. No. 91.*

By Phil M. Roedel. State of California, Department

of Fish and Game, San Pedro. Free upon request (paper). 184 + iv pp. + 1 pl.; text ill. 1953.

This is the second thorough revision by Roedel of the authoritative popular bulletin first authored by L. A. Walford in 1931. For identification—its chief purpose—it relies on numerous excellent halftones, brief and simplified diagnoses, and a single, much curtailed key. Numerous line sketches clarify diagnostic details and illustrate external structures used in classification. Almost all species likely to be encountered by commercial and sport fishermen are treated, and others are mentioned. Included are brief pertinent remarks on the importance of species, on fishing season and gear, and, occasionally, on life history and ecology. An effort has been made to standardize vernaculars.

CARL L. HUBBS

PHEASANT BREEDING AND CARE.

By Jean Delacour. All-Pets Books, Fond du Lac, Wisc. $3.00. xiv + 98 pp.; ill. 1953.

This is a "How To" book on raising pheasants of all kinds, written by an outstanding ornithologist. It deals very completely with such topics as shelter, breeding, rations, health, and state regulations. The photographs are attractive and there is a bibliography of 5 pages, but there is no index.

LORUS J. & MARGERY J. MILNE

THE CAGE-BIRD HANDBOOK. *With Chapters on Parakeets, Parrots, Macaws, and Other Parrotlike Birds.*

By Bernard Poe; illustrated by the author. G. P. Putnam's Sons, New York. $2.50. xii + 144 pp.; ill. 1954.

THE TROPICAL FISH BOOK. *Second Edition.*

By Ruthven Todd. Arco Publishing Company, New York. $2.00. 144 pp.; ill. 1954.

Both of these books are for home consumption. That on birds includes an elementary treatment of avian physiology and anatomy as well as detailed information on the care, handling, and training of these pets. Its few illustrations are of the linedrawing type, and are mostly of an anatomical nature. That on tropical fish is profusely illustrated with black-and-white photographs. Elaborate instructions, both pictorial and textual, are provided on tank construction and maintenance, aquatic plants, stocking an aquarium, and on the selection and care of fish. Over 100 species are pictured and described. The reader will probably find the book by Todd the more useful of the two because of its attention to specific details which plague fish fanciers, but both volumes are acceptable, readable, and handy to have on one's shelf.

C. P. SWANSON

MANUAL OF FIELD STUDIES ON THE HEAT TOLERANCE OF DOMESTIC ANIMALS. *Paper No. 38.*

Prepared by Douglas H. K. Lee. Food and Agriculture Organization of United Nations, Rome. $2.00 (paper). x + 162 pp.; ill. 1953.

This manual was prepared with the primary objective of providing the background information necessary for field studies of the adaptability of livestock to hot climatic conditions. It presents briefly and concisely the problems and general objectives of such studies and then goes into a more detailed discussion of the measurement of environmental conditions, animal reactions to these conditions, physical and productive characteristics of animals, and other factors influencing heat adaptation. The section on the measurement of environmental conditions lists each climatic factor and describes several alternative methods of measuring it. Each animal measurement is discussed under the subheadings Significance, Methods of Measurement, and Information Simultaneously Required. While this is by no means a complete treatise on the field study of heat tolerance and presents only a limited bibliography, it does make available to the animal husbandryman the information essential for the initiation of studies of this nature. It should be invaluable to persons commencing heat tolerance studies and could be used effectively by persons already engaged in these studies in expanding their research and standardizing methods. The last chapter, on the Interpretation of Field Studies and Application to Practical Production, presents some excellent concepts which should be considered by anyone interested in animal production in tropical and subtropical areas. The author is to be congratulated upon the compilation of a manual which brings together a vast amount of information not previously available in one work and upon presenting it in a form which is easily read and understood.

JAMES E. JOHNSTON

PRACTICAL TAXIDERMY. *A Working Guide.*

By John W. Moyer. The Ronald Press Company, New York. $3.00. viii + 126 pp.; ill. 1953.

Whether one wishes to mount a fish, reptile, bird, or mammal, prepare a game head or make a fur rug, this little book has the answer as to how it should be done. Even recommendations concerning the handling of specimens in the field are included. The necessary tools are described, formulas are given for every conceivable composition needed at any stage of any process, and all of the processes are described in clear detail and with abundant illustrations. Both rank amateurs and fledgling professionals will find much to increase their skill in the practice of this specialized art. The amateur will also appreciate the suggestions as to how some of the tools may be improvised from home materials. The author takes pains to explain that taxidermy is

now the art of "mounting" or "modelling" a specimen, and that "stuffing" is as passé as the dodo bird. With this, both reader and practitioner will agree.

BRYAN P. GLASS

ANIMAL CONTROL IN FIELD, FARM, AND FOREST.

By W. Robert Eadie. The MacMillan Company, New York. $3.75. viii + 258 pp. 1954.

The title of this book does not do justice to its scope. True, it contains a compilation of control measures for various species of mammals, but it also contains a summary of the natural history for each as well as a brief discussion of its economic status.

The text is divided into chapters, each dealing with one or a few families of mammals. These are all referred to by their common names for handy reference by the lay reader. Each chapter closes with a fairly extensive list of appropriate references.

While clear and detailed instructions on trapping and poisoning measures are given for each species, the author makes it clear by both statement and inference that he considers objective justification for control the first prerequisite. In his paragraphs on natural history and economic status it is also evident that in his opinion control measures are for the solution of local problems. Actually, in spite of its title, the book is distinctly a defense of the position usually taken by conservationists on this vexing problem of population regulation.

BRYAN P. GLASS

LIVESTOCK PRODUCTION. *Second Edition.*

By Walter H. Peters and Robert H. Grummer. McGraw-Hill Book Company, New York, Toronto, and London. $6.00. x + 416 pp.; ill. 1954.

The pattern established by the late Walter H. Peters in the first edition of this work has been kept virtually unchanged by the revising author. The book is intended primarily for the first course in animal husbandry at the college level. It is well suited for students in general agriculture or agricultural education who take only one course in animal husbandry. It is not intended for the student or livestock producer who is interested in the details of a particular species or class of livestock. The second edition has been rewritten in such a way as to incorporate the many advances in feeding and management which have occurred since 1942.

The first section of 7 chapters includes a general survey of the importance of livestock to man and the agricultural economy, and a brief summary of the development of animal breeding, nutrition, animal diseases, and livestock marketing. The last 5 sections deal with the problems of beef cattle, dairy cattle, swine, sheep and goats, and horses and mules, in that order. Every section includes chapters which summarize the general status, breeding, feeding, management, and judging of each class or type of farm animal.

FREDERICK N. ANDREWS

ANIMAL BREEDING. *Fifth Edition.*

By Laurence M. Winters, with chapters on Selection and the Effectiveness of Selection by William Rempel, and on Fertility and Artificial Insemination by John N. Cummings. John Wiley & Sons, New York; Chapman & Hall, London. $5.75. x + 420 pp.; ill. 1954.

There is a marked difference in the content and treatment of the several textbooks on animal breeding written in the United States. In some, major emphasis is placed on genetic applications, and in others, extensive basic information is presented in both reproductive physiology and genetics. Winters assumes that the reader has taken a course in basic genetics and is well grounded in physiology. He has devoted only 56 pages to reproductive physiology. This section provides a good review for the student who has a general understanding of the subject, but is somewhat brief for the beginner. It has likewise been presumed that the student is well grounded in genetics, and the general principles of genetics are only briefly reviewed.

The chapters on inbreeding, crossbreeding, purebred breeding, and on building superior germ plasm draw heavily on the author's experiences and observations. This section is interestingly written and has proved both popular and valuable to students and livestock breeders in previous editions. Two chapters on selection have been contributed by William Rempel, and there are chapters on fertility and artificial insemination by John N. Cummings. The textbook is written for the advanced undergraduate students in animal husbandry and emphasizes the applications of physiology and genetics to the breeding of farm animals.

FREDERICK N. ANDREWS

ANIMAL GROWTH AND DEVELOPMENT

THE ENERGETICS OF DEVELOPMENT. *A Study of Metabolism in the Frog Egg.*

By Lester G. Barth and Lucena J. Barth. Columbia University Press, New York. $3.00. xviii + 118 pp.; ill. 1954.

The Columbia University Press has marked the 200th year of Columbia University's existence by publishing several samples of current scholarship in a series of Bicentennial Editions and Studies. It is fitting that this important contribution is included among the titles selected for publication. In this brief, but well written, monograph, the principal facts concerning the metabolism of the frog egg are reviewed; yet the emphasis is not on past achievement, but on work in progress.

A considerable body of previously unpublished data is presented, and several possible areas of future work are outlined. The work is restricted largely to *Rana pipiens*, but studies on other species are included in a few instances in which data are not available for *R. pipiens*. For the most part, the authors have confined their attention to papers published since 1949. Although the works chosen for review are limited in number, the authors have, in my opinion, exercised sound critical judgment in selecting pertinent facts for consideration, and have achieved a synthesis, not merely a compilation, of the material. The introductory chapter states the aim of studies on the energetics of development and suggests a number of specific problems in the energetics of the embryo. In particular, the discussion of chemodifferentiation in the determination of cell types is excellent. Chapters 2, 3, and 4 deal with The Storage of Energy, The Release of Energy, and The Localization of the Release of Energy, respectively. These are good treatments of fields to which the Barths and their co-workers have made important contributions. The authors summarize and evaluate a number of lines of research and interject thoughtful comments and suggestions which demonstrate that their analysis of the data is based on first-hand experience with the material. The last, and largest, chapter deals with Protein Metabolism. It is concerned chiefly with recent analyses of the chemical and electrophoretic properties of the yolk proteins of the frog egg. The authors' findings are presented in detail; this chapter is not easy reading, but the unavoidable fact is that the field is complex and full of unsolved problems. I doubt that it would be possible to present so much material in any more straightforward fashion. The authors are careful to point out inconsistencies in the data, and make it clear that they are aware of the difficulties involved in applying data derived from studies on homogenates to the normal development of the embryo. The discussion of the sequence of findings leading to the tentative hypothesis that ATP may not act as a direct intermediary in the transfer of phosphate from phosphoprotein donor to acceptor, but rather that its function may reside in a control of the amount and locus of phosphoprotein breakdown (pp. 105–110), is penetrating and must be read carefully. *The Energetics of Development* is a modest and stimulating account of the progress and problems of one important aspect of modern embryology. It should be required reading for all serious students in the field.

JAMES D. EBERT

THE FETAL PIG. *A Photographic Study.*
By W. L. Evans and Addison E. Lee; photographs by George Tatum. Hemphill's, Austin. $1.25 (paper). 52 pp.; ill. 1954.

This spiral-bound photographic atlas is designed to supplement a laboratory manual of fetal pig dissection. The 40 photographs are of good quality, and cover the systems usually studied in this form; the muscular system is not considered. There is a corresponding identification key for the structures numbered on each photograph, and there is an index.

FRANK C. ERK

DEVELOPMENTAL ANATOMY. *A Textbook and Laboratory Manual of Embryology. Sixth Edition.*
By Leslie Brainerd Arey. W. B. Saunders Company, Philadelphia and London. $9.50. xii + 680 pp. + 1 chart; ill. 1954.

In the Preface to the Sixth Edition of his widely used textbook, Arey states that "no page and scarcely a paragraph remains as before, so that the present edition becomes essentially a new book." However, a comparison of it with the fifth and sixth editions reveals that most of the changes have been of a relatively minor nature; the aim, basic plan, and scope of the book remain essentially unchanged. The material in several large chapters has been reassembled into smaller, more workable units; for example, the former chapter on The Vascular System (55 pages) has been separated into two chapters: The Heart and Blood (24 pages); and The Vascular System (30 pages). The text has been rewritten "with an aim toward increased simplicity and clarity." In general this objective has been achieved. The treatment of several topics, viz., The Fetal Membranes, Placentation, and Reproductive Cycles and Their Hormonal Control, is outstanding. The section designed to serve as a laboratory manual for the study of the chick embryo has been strengthened in that a new section on the "72-hour embryo" has been included. It would have been helpful if, in addition to the descriptive terminology and chronological periods used in staging the chick embryo, the Hamburger and Hamilton stage numbers had been included. Like the last edition, the Sixth Edition is meticulously correct; very few minor errors have been noted. The illustrations are excellent.

The brief chapter dealing with Experimental Embryology and Teratology has been retained. In addition, a brief summary of pertinent information from the field of experimental embryology has been added following the description of the development of each organ or region. This supplementary information appears in small print under the heading "Causal Relations." In this manner, Arey shows his awareness of the growing interest in the experimental approach to problems of development. This innovation certainly represents an improvement over the past editions, in which such material was largely ignored. It is reasonable to expect that in future revisions of the book, this

material may not be isolated in small print, but woven skillfully into the main body of the text. In summary, the aim of *Developmental Anatomy* is to give an account of the development of man, with secondary attention to the basic features of development. That goal has been achieved remarkably well.

JAMES D. EBERT

AN OUTLINE OT DEVELOPMENTAL PHYSIOLOGY.

By Chr. P. Raven; translated by L. De Ruiter. McGraw-Hill Book Company, New York; Pergamon Press, London. $5.50. viii + 216 pp. + 10 pl.; text ill. 1954.

This translation makes available in English a lucid and thought-provoking, non-technical account of the principal facts and theories in developmental biology by one of the leading European investigators in the field. Although the book was written in 1942, the Dutch edition did not appear until 1948; during preparation of the present edition, the book was brought up to date by the incorporation of significant recent findings. *An Outline of Developmental Physiology* is intended for readers who are acquainted only with the first elements of biology. All too often such simplification results in inaccuracy and misstatement of fact. The author has demonstrated considerable skill in avoiding these dangers, and has written an accurate, straightforward summary of the major principles in his field. The technical terms employed are well defined, both in the text and in a brief glossary. This book can be read and understood by students who have had a sound basic course in general biology or zoology. It is not intended to be a textbook. Certainly it is not suitable for most conventional programs in embryology; yet in institutions in which the first course in embryology incorporates both descriptive and experimental material, it can be used profitably. It can be recommended to any beginning student in biology who expresses an interest in learning more about the mechanisms of development.

For a number of years Professor Raven has had a keen interest in the philosophical aspects of his science. His book reflects this interest; in every chapter the concepts of developmental biology are emphasized. In a brief concluding chapter the author compares and contrasts the vitalistic, organismic, and mechanistic views of development. His own point of view is expressed best by his final paragraph: "If now we ask whence this order of the egg originated, we can go still farther back in time, and trace the developmental processes which gave rise to the egg, but always again we encounter the order, given once and for all, which is the characteristic of all life. In the phenomena of life, all order is a consequence of previous order. Here we encounter the great enigma of Life, which cannot be solved by means of a causal approach. We must accept this order as an essential characteristic of life, a basic phenomenon, of which no causal explanation is possible."

JAMES D. EBERT

ANIMAL MORPHOLOGY

REPRESENTATIVE CHORDATES. *A Manual of Comparative Anatomy.*

By Charles K. Weichert. McGraw-Hill Book Company, New York, Toronto, and London. $3.50. viii + 204 pp.; ill. 1954.

The predecessor of this volume was a combined textbook and laboratory manual entitled *Anatomy of the Chordates*. The present book is essentially the second part of the earlier one presented separately, and with more elaborate instructions for dissection. Four classes of vertebrates are used, the lamprey, shark, mud puppy, and cat. They are treated consecutively, rather than simultaneously, by organ systems. An outstanding feature is the inclusion of numerous excellently reproduced illustrations and diagrams. Except for the diagram of the efferent arteries in *Squalus*, in which the terminology of the carotids is confused, the illustrations are accurate.

I have found personally that with such a profusion of illustrations some students tend to rely too heavily upon them, at the expense of individual dissection. A section on the anatomy of the protochordate *Amphioxus* would be a valuable addition.

BRYAN P. GLASS

ANIMAL PHYSIOLOGY

PORPHYRINS. *Their Biological and Chemical Importance.*

By A. Vannotti; translated by C. Rimington. Hilger & Watts, Hilger Division, London. 50s. viii + 258 pp. + 15 pl.; text ill. 1954.

The occurrence of the basic porphyrin structure in substances of biological importance has been under investigation for a number of decades. The literature on the subject is not only extensive but also somewhat complex, running the gamut from hemoglobin to turacin, the pigment found in feathers of *Turacus*, tropical birds of central Africa. This volume is a rather limited descriptive treatise on porphyrins which has been translated from the French by C. Rimington. It is devoted to considerations of the biological and clinical importance of the pigments. The coverage of the chemistry of the porphyrins is not extensive; however, considerable attention is devoted to the subject of porphyria, the increased elimination of porphyrins, and to the treatment of porphyrin diseases.

One of the sections, useful to those who become involved in the qualitative and quantitative determination of prorphyrins, is devoted to the available methods of extraction and separation. Numerous references are provided for those interested in greater detail as to the specific porphyrins. As is inevitable when a delay occurs in publishing, the newer findings of Shemin et al. concerning the glycine-succinate cycle in porphyrin synthesis have not been included in the text.

R. Van Reen

Les Plaquettes Sanguines de l'Homme.

By Bernard Maupin. Masson & Cie., Paris. 2,000 fr. (paper). vi + 272 pp.; ill. 1954.

This book contains an excellent discussion of human blood platelets in the light of modern knowledge. After a brief historical sketch, the relevant techniques are given in Chapter II. Separation and counting techniques are given special emphasis. (Later chapters also have technical appendices.) Chapter III discusses the life and function of platelets, and their preservation. The morphology is presented in Chapter IV, which takes account of recent research and the dynamic aspects of the formed elements of the blood.

The biological study of platelets is developed in the four following chapters, which contain physical, chemical, biochemical, and physiological findings. Chapter IX, dealing with immunology, devotes considerable space to modern work on anti-platelet antibodies, and forms the transition between the normal and the pathological. Chapter X discusses the physiological and pathological variations of platelets, and Chapter XI presents the aspects of platelet pathology which the author considers instructive (the role of the spleen, immunological factors in the origin of purpuras, role of the platelets in hemophilia, and role of the platelets in clotting).

Chapter XII is devoted to the practical use of platelets in therapy and especially to the transfusion of platelets. Chapter XIII attempts to answer the question "Is the platelet a living cell?" The author concludes with Wright that the platelet is a detached fragment of the cytoplasm of the megakaryocyte.

The book is well printed on good paper, and is paperbound. There are 23 illustrations, a table of contents at the back, and an index.

William C. Boyd

Blood Cells and Plasma Proteins. *Their State in Nature.*

Edited by James L. Tullis. Academic Press, New York. $6.50. xxi + 436 pp.; ill. 1953.

The contents of this book are based upon the second in a series of seminars held at Harvard University in the Spring of 1951. Several manuscripts, however, include data published in 1952.

The many contributors, headed by the late E. J. Cohn, represent an authoritative group with diversified interests as related to blood. The book is divided into 7 sections which cover the following general topics: formed and fluid parts of human blood; blood coagulation; blood components involved in immunity; erythrocytes; leucocytes; plasma enzymes; and the lipoproteins of blood and other tissues. For reference purposes, both a subject and author index are appended. Almost all of the sections and many of the separate chapters are introduced by a few paragraphs of historical background material.

Our ideas relating to blood and its components have undergone many changes in the past two decades. The newer concepts of protein-protein and protein-metal interaction, of platelets in coagulation mechanisms, of white cells in immunology, and of plasma and erythrocyte enzymology—to mention but a few—are ably presented and discussed. The volume outlines some methodology more recently applied to the study of blood. Many of the authors are also directly or indirectly concerned with the application of recent findings to the preservation of blood components.

Topics which were included in the seminar but omitted from this volume are, according to the editor, to be incorporated for the most part into volume 3 of the series. Although the editor's preface outlines the scope and contents of the book, the lack of a summary is noticeable. This is, however, a very minor defect of an otherwise superior symposium.

Blood Cells and Plasma Proteins deserves to be on the bookshelf of everyone concerned with the biochemistry and physiology of blood. Also, readers whose special training does not lie within these two fields of biology will be pleased to find that (with but few exceptions) the symposium is so presented as to enable them to obtain a good understanding of the subject matter.

Claude Baxter

Transfusion Sanguine et Actualités Hématologiques. *Premier Congrès National des Transfusions Sanguines de France et des Pays de Langue Française, Alger, April 1953.*

Published under the direction of Ed. Benhamou and And. Albou; 119 authors. Masson & Cie., Paris. 4,000 fr. (paper). ii + 672 pp.; ill. 1954.

This book contains the text of 88 papers presented at the First National Congress of Transfusion of France and the French-speaking countries, held April 1–4, 1953, in Algiers. It also contains abstracts of some 80 papers presented at the congress, and extracts from addresses given the congress by the Governor-General of Algeria, by Prof. Van Loghem, Prof. Hermann, and Surgeon-General Jame.

The papers are arranged into three categories: (1) social and military aspects of transfusion, techniques, and blood grouping; (2) clinical and therapeutic problems relating to erythrocytes, leukocytes, and platelets; coagulation, and disorders of the hematopoietic system; and (3) the indications for transfusion in medicine, surgery, obstetrics, urology, etc.

A large number of authors is represented, not all of them French by any means. The papers vary greatly in length and usefulness, but on the whole are of about the caliber usually presented at such congresses. The book is well printed, on good paper, and has 100 illustrations. It is bound in paper and has a table of contents at the back, but no index.

WILLIAM C. BOYD

BLUTGEFÄSS- UND LYMPHGEFÄSSAPPARAT INNERSEKRETORISCHEN DRÜSEN. DIE NEBENNIERE—NEUROSEKRETION. *Handbuch der mikroskopischen Anatomie der Menschen. Sechster Band. Fünfter Teil. Founded by Wilhelm v. Möllendorf; continued by Wolfgang Bargmann.*

By R. Bachmann and E. and B. Scharrer. Springer Verlag, Berlin, Göttingen, and Heidelberg. DM 342.– (paper). xv + 1199 pp.; ill. 1954.

This book, the first part of the von Möllendorff-Bargmann *Handbuch* to appear since the war, covers two important fields of internal secretion. Most of the volume is written by R. Bachmann and is a thorough canvass of the literature on the adrenal glands. It consists of 952 pages, of which 183 are filled with references closely set in small type. After a brief history of the discovery and early investigation of the adrenal, the main divisions of the work deal with the comparative anatomy, embryology, abnormalities of development, gross and microscopic anatomy, histochemistry, vascular and nerve supply, and histophysiology of that organ. The last division, on the function of the gland, occupies one third of the monograph. The adrenals have many, important, complex, and often poorly understood interrelations with the other endocrine glands and with other tissues and organs. The intricacies of these functions and the dramatic effects following the introduction of potent hormones isolated from the gland make it obvious that the mass of data in this field cannot be summarized briefly. Accordingly, Bachmann has produced a book that is largely a detailed abstract of most of the pertinent literature. Much emphasis is laid on the histochemical analysis of the glands and on their relationships to the rest of the body. The problem of the reaction to stress is gone into in considerable detail. This monograph is an indispensable contribution to anyone seeking orientation in the general field of the morphology and function of these exceedingly important endocrine glands. It is well illustrated with the outstanding figures of the literature and with a few original ones. In his final, very brief summary, Bachmann ventures to speculate a bit on the nature of the adrenal glands, and compares their relationship to the peripheral nervous system with that of the hypophysis to the midbrain, both glands participating in the neuro-humoral regulation of the body. My only serious criticism of the monograph is that it is often verbose, a common failing of reviews written by Germans. This abstract of the literature on the adrenals reflects the dilemma faced by all of us who are struggling with the rapidly increasing flood of books, abstracts, and review journals in our particular fields of biology. We can sympathize with Bachmann as he plowed through the enormous literature on the adrenals, and I am sure that workers in the field will feel indebted to him even though they may disagree with him in some details of interpretation.

The rest of the volume contains the much shorter contribution of Ernst and Berta Scharrer on neurosecretion, a subject to which, after the early work of Speidel, they have contributed so much. In their own work they have approached the problem of neurosecretion from a comparative point of view, beginning with the invertebrates, and the presentation in this monograph follows the same plan. For many invertebrates they report a good correlation between the occurrence of morphological evidences of secretion by nerve cells and the demonstration of their hormonal effects on chromatophores, reproduction, growth, metamorphosis, metabolism, and on other endocrine organs. They have found that the only neuro-secretory cell complex which is present in all vertebrates is the nucleus preopticus in the lower forms and the homologous supraoptic and paraventricular nuclei in reptiles, birds, and mammals. With their own work, and that of others, especially Bargmann and his students, they have built up a strong case for their thesis that the hormones which can be extracted from the posterior lobe of the pituitary are actually secreted by nerve cells in the hypothalamus. The article is well illustrated with drawings and fine colored photomicrographs.

WILLIAM BLOOM

LE CORTEX SURRÉNAL. *Les Bases Morpho-Physiologiques de sa Connaissance; son Role dans la Pathologie et la Thérapeutique.*

By A. Cellestino Da Costa; with the collaboration of R. Iriarte Peixoto. Masson & Cie., Paris. 1300 fr. (paper). vi + 186 pp.; ill. 1952.

This little volume includes chapters on adrenal cortical morphology, physiology, biology, histophysiology, pathology, and therapeutics, and was avowedly written for clinicians as a review of current knowledge. The bibliography is restricted to a short list of monographs and reviews. Da Costa is a professor of the

medical faculty of Lisbon. There is a good deal of necessarily tentative discussion of histophysiology and embryology. This is combined with a relatively concise presentation of a substantial amount of material of more immediate clinical relevance.

EVELYN HOWARD

THE PINEAL GLAND. *A Review of the Physiologic Literature.*

By Julian I. Kitay and Mark D. Altschule. Published for the Commonwealth Fund by Harvard University Press, Cambridge. $5.00. xiv + 280 pp. + 5 pl. 1954.

This is an admirable and much needed objective survey of the physiologic literature on the pineal gland. It includes detailed evaluations of data, and extended consideration of appropriate papers. Statistical information is given when available. The bibliography includes 1028 references to studies on pineal physiology, including clinical correlations, 514 on anatomy, embryology, and histology, and 220 reviews. A considerable amount of research done in Japan and continental Europe is included. Discussions of speculative material have largely been omitted from the text, which consists of a modest 104 pages. The experiments reviewed show that the pineal cannot be considered either functionless or vestigial, but that it exerts endocrine effects which in some respects seem to operate in opposition to the pituitary gland. The pineal has, furthermore, a very high rate of uptake of radioactive phosphorus. Endocrinologists will be indebted to the authors for a contribution in the tradition of scholarship at its best, which may be expected to become a classical landmark in a field which has suffered from more than its share of half-hearted guesswork.

EVELYN HOWARD

ENDOCRINE IMBALANCE AND TISSUE HYPERPLASIA IN TELEOSTS MAINTAINED IN DARKNESS. *Bull. Amer. Mus. nat. Hist., Vol. 104, Art. 4.*

By Priscilla Rasquin and Libby Rosenbloom. American Museum of Natural History, New York. $1.25 (paper). Pp. 359–426 + 20 pl. + 1 diagram. 1954.

THIRD ANNUAL REPORT ON STRESS.

By Hans Selye and Alexander Horava. ACTA, Montreal. $10.00. 638 pp.; ill. 1953.

This volume is similar in its organization to the other two Annual Reports on Stress, except for a longer Sketch for a Unified Theory of Medicine and a special article on hypertension.

ECKHARD H. HESS

THE GREEN AND RED PLANET. *A Physiological Study of the Possibility of Life on Mars.*

By Hubertus Strughold; with editorial assistance and a foreword by Green Peyton. The University of New Mexico Press, Albuquerque. $4.00. xx + 108 pp.; ill. 1953.

The approaching possibilities of a space trip to Mars inevitably raise the questions of what we will find in the way of life when we get there, and what we will have to take with us to survive on that planet. The author, who bears the intriguing title of Head, Department of Space Medicine (USAF), seeks to provide possible answers by taking known astrophysical data and considering these in terms of the physiology of life as we know it. There seems to be no problem of temperature, since that of Mars, and of Venus, too, lies within the proper physiological range; there is, however, the bigger problem of an adequate oxygen supply. At present the atmosphere of Mars is far below the minimum oxygen levels necessary to sustain all except the most anaerobic of forms, and Strughold concludes that at most only a very primitive life, if any, will be encountered by the first visitor. This will be reassuring news, indeed, to those who worry about flying saucers and Martians, and we recommend that it be translated into French in order that the Frenchman who meets one of those little green men in his vineyard can march up to him in dignity and denounce him for the obvious fraud that he must be.

C. P. SWANSON

BIOPHYSICS AND GENERAL PHYSIOLOGY

BIOLOGICAL EFFECTS OF EXTERNAL X AND GAMMA RADIATION. *Part I. First Edition.*

Edited by Raymond E. Zirkle. McGraw-Hill Book Company, New York, Toronto, and London. $7.25. xxvi + 530 pp.; ill. 1954.

BIOLOGICAL EFFECTS OF EXTERNAL RADIATION.

Edited by Henry A. Blair. McGraw-Hill Book Company, New York, Toronto, and London. $7.00. xviii + 508 pp.; ill. 1954.

Both of these volumes deal with wartime research done under the sponsorship of the Manhattan Project, the multitentacled anonymity that spawned the atomic bomb. The biological research was a necessary part of the overall picture that had to be comprehended, and what little radiobiological information there was prior to the War was insufficient to provide anything other than arrows which pointed in this direction or that, as roads to travel. The work reported in these two volumes obviously lacks unity and comprehensiveness, but the haste and rigid security that prevailed during the war are in large part responsible for this state of affairs.

The volume edited by Zirkle reports studies which

were carried out at the Metallurgical Laboratory, University of Chicago, and the National Cancer Institute, Bethesda, Md., and which were "directed toward an understanding of radiobiological actions on mammals and on man in particular." The general goal was an understanding of the effects of total-body radiation, either long-continued or at relatively high intensities, with mice, guinea pigs, and particularly rabbits as the experimental animals. Aspects of blood changes, mortality, breeding behavior, pathological responses, hemorrhaging, enzyme and immunological activity, tissue metabolism and permeability, and protection, together with radiation-induced changes in the UV absorption of urine are considered. The numerous graphs and tables summarize the vast amount of work which led to these reports, but no comprehensive summary is provided to integrate these diverse data or to incorporate them into the general body of radiobiology. The editor is well aware of this shortcoming, but the lack of communication between laboratories during the War, and the post-war scattering of research personnel made such integration almost impossible. The reader is consequently forced to do his own summarizing, except where fragments of this work have been made public and have been assimilated in other radiobiological publications.

Blair's volume is concerned principally with the biological effects of x-radiation, together with a consideration of the chronic effects of neutron irradiation. This work was done largely at the University of Rochester and at the Biochemical Foundation, Newark, Delaware. As in the volume edited by Zirkle, both single-dose and chronic effects are considered, with some overlap in aims and results. The major objectives, however, were somewhat more specific, being directed toward the descriptive aspects of lethality, the development of critical criteria for the detection of minimal effects of radiation, and the determination of pathological and genetic effects of both acute and chronic radiation. The second objective, unfortunately, was never attained, and remains today a rather large gap in any effective health physics program.

Despite the disjointedness of both volumes, the information contained in them forms a most significant contribution to our understanding of radiological effects, and to the development of safe radiological procedures. Both volumes should be required reading for every medical man who make use of x-rays for diagnostic and therapeutic purposes.

C. P. SWANSON

ACTIONS OF RADIATIONS ON LIVING CELLS. *Second Edition.*

By the late D. E. Lea. Cambridge University Press, New York. $6.00. xiv + 416 pp. + 8 pl.; text ill. 1955.

Although listed as a second edition, the present volume can scarcely be considered such, since it differs from the first (*Q.R.B.*, 22: 330. 1947) only by certain corrections in the Tables and by an appendix which has been added by L. H. Gray and which is derived from notes which the late Dr. Lea left at his death. Even so, it is important to note that Lea's book is again in print, for it is without doubt the single most important contribution to radiobiological literature that we have and its influence is recognized by all who work in this area of research. It is to be hoped that some day someone will step into Lea's shoes to provide again a critical appraisal of this field, an appraisal which is needed because of the increasing volume of data on the role of oxygen in radiation effects, on the radiomimetic effects of chemicals, and on the physical aspects of biologically important molecules. Until such a time, this book constitutes the best bridge that we have between the physical and the biological aspects of a still active and important field of research.

C. P. SWANSON

BIOCHEMISTRY

BIOCHEMISTRY.

By Abraham Cantarow and Bernard Scheparts. W. B. Saunders Company, Philadelphia and London. $11.00. xxvi + 848 pp.; ill. 1954.

It would be more nearly correct to call this a biochemical dictionary rather than a textbook of biochemistry. It is designed for first-year medical students. The authors point out in the Introduction that it has been their experience that students at all stages of medical education generally have a poor comprehension of biochemistry. Under these circumstances it would seem that what is really needed is a solid foundation of basic biochemical knowledge rather than an enumeration of biochemical facts. If the first-year students do not appreciate the scientific method and how it can be applied to specific biochemical problems, they will have missed the whole point of biochemistry.

The book is well organized and the subject matter is up to date, especially with regard to such topics as vitamins, hormones, metabolic antagonists, and allied medical subjects. However, the principles of biochemistry are covered in an arbitrary fashion. The emphasis seems to have been placed on an extensive series of cross references and a voluminous index. Whether these will help the student to understand biochemistry is questionable.

G. R. NOGGLE

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume 23.*

J. Murray Luck, Editor; associate editors, Hubert S. Loring and Gordon MacKinney. Annual Reviews, $7.00. x + 636 pp. + 1 pl. 1954.

This series is so well known to chemists and biologists that it should be sufficient to say that the contributors to the present volume have maintained the high standards found in the previous volumes. The prefatory chapter features an autobiographical sketch by Karl Thomas, entitled Fifty Years of Biochemistry in Germany. The review articles are as follows: Biological Oxidations (C. B. Anfinsen and W. W. Kielly); Proteolytic Enzymes (P. Desnuelle); Chemistry of the Carbohydrates (R. L. Whistler and D. I. McGilvray); Nucleic Acids (F. W. Allen); Carbohydrate Metabolism (S. Weinhouse); Chemistry of the Proteins, Peptides, and Amino Acids (W. L. Hughes and F. M. Sinex); Fat-Soluble Vitamins (M. L. Quaife); Water-Soluble Vitamins, Part I (E. Lester Smith); Water-Soluble Vitamins, Part II (V. H. Cheldelin and T. E. King); Nutrition (P. H. Phillips and M. A. Constant); Biochemistry of Cancer (A. C. Griffin); The Biochemistry of Muscle (W. F. H. M. Mommaerts); Biochemistry of Hormones—Restricted to Pituitary and Adrenal Interrelationship (M. P. Stack-Dunne and F. G. Young); Clinical Applications of Biochemistry (I. D. P. Wootton, M. D. Milne, and E. J. King); Mineral Metabolism—Animal (G. K. Davis and J. K. Loosli); Thyroid Hormones and Iodine Metabolism (J. Roche and R. Michel); Metabolite Antagonists (R. O. Roblin, Jr.); and Nonoxidative and Nonproteolytic Enzymes (H. M. Kalckar and H. Klenow).

G. R. NOGGLE

PAPER CHROMATOGRAPHY. *Second Edition.*

By Friedrich Cramer; translated by Leighton Richards. Macmillan & Company, London; [St. Martin's Press, New York]. $5.00. xii + 107 pp. + 3 charts; ill. 1954.

This is an English translation of the second German edition. The foreword was written by Consden who, with Martin and Gordon, was largely responsible for introducing the technique of paper chromatography. The book is amply illustrated with drawings and pictures of apparatus as well as numerous tables of R_f values. Full details are given for the separation of amino acids, sugars, alcohols, phosphoric acid esters, nucleic acid derivatives, and other biologically active materials. A person unfamiliar with paper chromatography could, with the aid of this book, obtain a workable knowledge of the technique.

G. R. NOGGLE

MODERN ASPECTS OF pH *with Special Reference to Plants and Soils.*

By James Small. D. Van Nostrand Company, New York. $5.00. xii + 248 pp. + 3 folded tables; text ill. 1954.

Most biologists have a slight knowledge of pH and pH meters. The significance of the term pH is not so well understood, and what one measures when pH is determined is even less understood. It is pointed out in this book that the fundamental concepts of pH have changed during recent years, and the author attempts to correlate this new knowledge of pH with a number of biological phenomena chiefly dealing with plants and soil. There is also included a valuable survey of methods available for measuring the pH (or hydrogen-ion activity) of biological systems. The book is mainly of interest to botanists and ecologists, but all biologists would benefit from reading it.

G. R. NOGGLE

MICROBIOLOGY

MICROBES AND YOU.

By Stanley E. Wedberg. The Macmillan Company, New York. $4.50. x + 440 pp.; ill. 1954.

If survey courses in bacteriology continue to exist, this book qualifies well as a companion and was so intended by the author. Written in a reasonably popular style, new technical terms are emphasized in small capitals and are sufficiently well defined for the casual reader. Boring detail is not encountered under any of the topics discussed, and almost every facet of bacteriology is mentioned. The colorful history of bacteriology is well presented and leads into a discussion of bacteria and other organisms with many physiological aspects stressed. Approximately one-third of the text is devoted to those aspects of bacteriology which form a part of our everyday life, and which therefore would be of most useful value to the student of a survey course. Some ingenuity on the part of the lecturer will be necessary, however, in order to prevent the students' assimilation of a warped knowledge of bacteriology. Unfortunately, too little space is allowed to the beneficial bacteria in relation to their relative occurrence in nature. Those chapters devoted to the pathogenic species contain sufficient information to correct many of the old wives' tales which persist. Scattered through several sections of the book are discussions concerning the human organism, including chapters on resistance and blood grouping.

As the above comments indicate, the book is suitable for a survey course in bacteriology. It is definitely not to be recommended for use by students majoring in bacteriology or in related fields.

R. D. DEMOSS

TEXTBOOK OF MICROBIOLOGY. *Sixteenth Edition.*

By William Burrows; with the collaboration of Francis Byron Gordon, Richard Janvier Porter, and James William Moulder. W. B. Saunders Company,

Philadelphia and London. $11.00. xx + 824 pp.; ill. 1954.

This volume is the successor to the fifteenth edition of the Jordan-Burrows *Textbook of Bacteriology* (1949). There have been a number of changes in detail and up-dating, but the authorship and general plan remain the same. The book will doubtless retain the same popularity for the teaching of bacteriology in the medical schools as its predecessors have enjoyed.

It is becoming increasingly difficult for any single person to enjoy authoritative competency in so broad a field as "microbiology." The contributions of the junior authors in the respective fields of virology, parasitology, and biochemistry are an important concession to this realization. The principal author must still remain responsible for taxonomy, infectious disease and immunity, genetics, biophysics and radiobiology, cytology, epidemiology, chemotherapy, pathology, and public health. In exchange for the certain advantages of a text with a uniform standard of presentation, any treatment such as this must necessarily lose in precision within some of the diverse fields mentioned. Perhaps this will account for such startling bits of incomprehension as the statement that the "lethal dose" of ionizing radiation of *Escherichia coli* is so many roentgens, and a similar treatment for thermal disinfection (though happily not for chemicals). More significant to medical students is some ambiguity in the treatment of Vi antigen, perhaps because of the separation of the typhoid and other species of *Salmonella* in distinct chapters. At one point, Vi is said to be heat stable, at another it is heat labile in the presence of water, and the author's views on its role in immunity are equally equivocal. To insist that "the efficacy of typhoid immunization is undoubted" is to pass over one of the most vehement and engaging of the controversies currently raging among students of infectious disease.

A text of this scope, in a rapidly expanding field, is bound to contain any number of such variants of interpretation. Unfortunately, students in the medical schools are not always encouraged to adopt a sceptical attitude toward their textbooks; perhaps a few more obvious blemishes would be all to the good. By and large, the authors have done a serviceable job that warrants the confidence already proven by the widespread adoption of the textbook. They are particularly to be commended for their adherence to the stated emphasis of the interrelationships of microbes in their fundamental structure, as well as their ecology, with other forms of life.

J. LEDERBERG

ANNUAL REVIEW OF MICROBIOLOGY. *Volume 8. Edited by Charles E. Clifton; associate editors, Sidney Raffel and Roger Y. Stanier. Annual Reviews, Stanford.* $7.00. viii + 536 pp. 1954.

In a review of a previous number of this series (*Q.R.B.*, 29: 91. 1954) it was suggested that the scope of individual topics was so broad that it was too much to expect a careful, analytical résumé. It is gratifying to note that these reviews are now evolving away from summary bibliographies toward becoming critical analyses of carefully selected, narrower topics. One exception here is the treatment of the genetics of microorganisms (Spiegelman and Landman); but, within the scope of 56 pages and 481 citations, these authors have managed a tour-de-force of its own kind, although at times they have taken pains to conceal their intended meaning, e.g., in regard to terminological questions, and "pleiotrophism" (sic). This and many other chapters make for an excellent volume, well worth its price—which, for these days, is quite modest.

While it would be hopeless to try to review these reviews, the topical coverage is well worth listing: Bacterial Cytology (Mudd and Delamater); Nutrition (Hendlin); Metabolism (Campbell); Autotrophs (van Niel); *Leptospira* (Schlossberger and Brandis); *Plasmodium* (Garnham); Antibacterial Mechanisms (Umbreit); "Bacterial Virus (With special reference to the synthesis of)" (Evans); Modification of Indigenous Flora (McCoy); Protozoal Infections (Maegraith); Hepatis and other Viruses (Havens); Influenza Variation (Hilleman); Labelled Antigens and Antibodies (Coons); Polysaccharides from Animal Parasites (Oliver-Gonzalez); Non-specific Factors in Immunity (Nungesser); Oncolytic Viruses (A. Moore); Toxins (Oakley); Dairy Products (Jezeski); Fungi for Food (Thatcher); and Cytopathology of Virus Infections (Enders).

J. LEDERBERG

SEX IN MICROORGANISMS. *A symposium presented on December 30, 1951, at the Philadelphia meeting of the American Association for the Advancement of Science. Editorial Committee, D. H. Wenrich, Chairman and Editor, Ivey F. Lewis, and John R. Raper. American Association for the Advancement of Science, Washington.* $5.75. (AAAS Members, $5.00). vi + 362 pp.; ill. 1954.

Although the papers in this volume were presented at a AAAS symposium in 1951, the coverage of the subject is somewhat more recent, for citations extend into 1952 and 1953, and is also more extensive than the symposium itself would have indicated. The organisms discussed include the bacteriophages, bacteria, fungi, algae, diatoms, and protozoa. It is quite apparent that "sex" is expressed in a multiplicity of ways among these lower forms, and equally so that a definition of sex will depend upon the available data and the approaches which have been taken in the investigation of this phenomenon.

Among the bacteriophages (Visconti) and the bacteria (Lederberg and Tatum; Hutchinson and Stempen)

sex is known only so far as the genetic evidence can be translated into end results equivalent to those obtained from higher organisms where chromosomal mechanisms for sex determination are prevalent. The morphological evidence is fragmentary, and what is available is variously interpreted. The complexity of sexuality in the fungi (Raper) is bewildering indeed, and is matched by a similar complexity of life cycles and sexual mechanisms, yet the genetic, physiological, and morphological studies nicely complement each other to give a reasonably clear picture. Perhaps the clarity evident here as contrasted to that in bacteriophages and bacteria can be attributed to the fact that mycology is an old and honorable science, while sex in the other two forms has only recently been considered a possibility. Sexual differentiation in the diatoms (Patrick) is uncertain, although fusion of cells can be followed, while among the unicellular algae (Lewin) only the Volvocales appear to be suitable for studies of this sort. Of particular interest in Lewin's article is the discussion of the results of Moewus as contrasted with those of other investigators, and the coverage of the physiological mechanisms involved in the proper functioning of sexuality. Wenrich, in a most extensive review, deals with the protozoa, and although he covers briefly the hormonally controlled sexual expression of the flagellates found in the gut of the wood-eating roach, it is advisable to make use of Cleveland's original papers on this subject. Mating types and mating substances in *Paramecium* are dealt with by Nanney and Metz, respectively, while Wenrich provides a final and inconsequential chapter upon the origin and evolution of sex. Surprisingly enough, sexual mechanisms as devices for genetic recombination receive no comment as to evolutionary importance, although the underlying theme, implicit or explicit, of the other papers is that this is the central contribution of sex to evolution, other devices being secondary.

C. P. SWANSON

HEALTH AND DISEASE

HYPERTENSION. *Humoral and Neurogenic Factors. Ciba Foundation Symposium*

Editors for the Ciba Foundation, G. E. W. Wolstenholme and Margaret P. Cameron; assisted by Joan Etherington. Little, Brown & Company, Boston. $6.75. xiv + 294 pp. + 3 pl.; text ill. 1954.

In his opening remarks, G. W. Pickering, Chairman of the Symposium, said, "Twenty-two years ago, when I started to work on hypertension . . . it seemed to me this would be a relatively simple problem to solve. All it needed was the application of the experimental method and physiological principles. It is rather sad to look at it again after twenty-two years, and see that I have to count myself amonst those who do not know the answers to most of the questions that we ask."

In reading the twenty-one papers presented by scientists from more than a dozen countries, one is impressed, on the one hand, by the increasing complexity of the experimental approach and, on the other, by the tenuousness of many of the results in so far as they illuminate the riddle of human hypertension. The most recent concepts are presented regarding reflex blood pressure regulation, pressor and depressor substances, and the roles played by the kidney and adrenal gland, with particular reference to the retention and maldistribution of sodium and water. The discussion of each paper is reported in detail and gives a vivid portrayal of the differing attitudes of the investigators toward the central problem. As a whole, the symposium provides a stimulating but somewhat confusing glimpse of the field of experimental hypertension and those who toil therein. It should be read by students of hypertension, but is not suited for general medical reading.

CAROLINE BEDELL THOMAS

THE STATUS OF MULTIPLE SCLEROSIS. *Ann. N. Y. Acad. Sci., Vol. 58, Art. 5.*

Edited by Roy Waldo Miner; consulting editor, Harold R. Wainerdi; 39 contributors. New York Academy of Sciences, New York. $4.50. ii + pp. 541–720; ill. 1954.

An introduction and 21 research summaries comprise this little monograph on a still baffling illness. The material is presented in three parts: Biological and Pathological Methods; Biochemical Methods; and Clinical Methods. Almost all of the contributions provide references, and many of them include comments by members attending the conference (held in April, 1953).

LORUS J. & MARGERY J. MILNE

PRACTICAL MYCOLOGY. *Manual for Identification of Fungi.*

By Sigurd Funder. Stechert-Hafner, New York; Brøggers Boktrykkens Forlag, Oslo. $6.50. 146 pp.; ill. 1953.

The book is intended as an introduction to mycology for beginners, and for bacteriologists, physicians, and others without specialized training in botany, who are interested in identifying the most common fungi encountered in their work. It is based on a series of drawings by J. W. Wilson and O. A. Plunkett, distributed under the title *Practical Medical Mycology: The Identification of Fungi by Microscopic Examination.* The scope of this earlier series of drawings has been considerably expanded in an attempt to cover the fungi of particular interest in general mycology and in plant pathology, as well as in medical mycology.

Much can be said in favor of the idea upon which this

book is based. To me, its principal defect is that there is not enough of it. The coverage in the area of medical mycology is adequate, and includes a key to the human mycoses by Morris A. Gordon which has previously appeared in the *Journal of Bacteriology*. But it is particularly in the field of plant pathology that the deficiency in the quantity of material included comes to light. While the number of plant diseases of economic importance is possibly several thousand, and the majority of these are due to fungi, the treatment of the Ascomycetes of plant pathologic importance, for example, consists of *Taphrina*, four genera of powdery mildews, *Nectria*, *Claviceps*, *Mycosphaerella*, *Venturia*, *Pleospora*, *Pseudopeziza*, and *Sclerotinia*. Similarly, in the general mycology section, the Basidiomycetes are dealt with in 3 pages. One may well wonder how practical the present volume is likely to be in fulfilling its announced objectives.

The line drawings, which form the principal portion of the work, are well done, and convey a wealth of information. The fundamentals of elementary mycology, the classification of fungi, and laboratory methods for study of fungi are dealt with concisely in about 30 pages. There is a glossary and an index. We should like to believe that a place exists for a future book, built along the plan of the present one, but several times larger, in which the simplicity of presentation could be preserved while a more adequate coverage of the field was provided.

F. T. Wolf

Les Réactions Organiques non Spécifiques en Dermatologie. *Colloq. Filiale Marseillaise Soc. Fr. Dermatol. Syphiligr., Marseille, 19, 20, 21, Octobre, 1951. Edited by Jacques Charpy. Masson & Cie., Paris.* 3500 fr. (paper). 524 pp.; ill. 1952.

In order to review this book critically and accurately one would need a very precise knowledge of French (which I do not possess) and furthermore one should also be an accomplished chemist, physiologist, pathologist, endocrinologist, internist, allergist, and dermatologist. The following 13 subjects are discussed: nonspecific cutaneous reactions; the syndrome of irritation; the syndrome of general adaptation; the diseases of adaptation; a pathogenetic concept of the ensemble of medicine; diffusion factors and their hormonal control; inflammation and cortisone; collagenous tissue diseases; allergy in dermatology in its relationship to cortisone; allergy in dermatology in its relationship to the genital hormones; treatment with ACTH, cortisone, and the adrenal cortex derivatives; the etiology problem in psoriasis; the therapeutic problem in psoriasis.

The above subjects are presented and discussed by 43 different authors. Some chapters are summarized not only in French but also in English, Italian, or Spanish. The bibliographical lists following most of the chapters are very long. In general the book may be said to represent a very wordy French viewpoint, now three years old. I do not think it will attract many American readers.

W. Hanford Hopkins

An Introduction to Pathology. *Second Edition. By G. Payling Wright. Longmans, Green & Company, London, New York, and Toronto.* $7.50. xii + 636 pp.; ill. 1954.

This book, first published in 1950 (*Q.R.B.* 27: 328. 1952), was unique in stressing the experimental and physiological approach to the understanding of disease. In this, its second edition, every chapter has been reedited and much recent information has been incorporated. Among these additions are accounts of the effects of cortisone and other therapeutic agents, electron microscopic studies on the effects of viruses on cells, and newer concepts of the relation of genetics to disease. Two important new chapters have been added to the book. In one, the nature of hypersensitivity and the role of inflammation in allergic reactions are discussed. The other chapter concerns the nature of ionizing radiations and the tissue reactions they produce. These are excellent contributions to the understanding of basic problems in general pathology. This book, therefore, continues its role as a valuable supplement to the conventional textbook of pathology.

Ella H. Oppenheimer

The Concept of Schizophrenia. *By W. F. McAuley; foreword by John H. Ewen. Philosophical Library, New York.* $3.75. 146 pp. 1954.

A well-intentioned effort has been made in this book to review current concepts of schizophrenia, to retrace their historical development, and to reappraise palpable weaknesses in present psychiatric knowledge. What the author has accomplished is to demonstrate that the widely diversified investigations of the past fifty years have produced "much divergence of opinion in the interpretation of the facts obtained and their relative values in the theories of causation."

Although metabolic, neurophysiological, and genetic studies are surveyed in brief chapters, as is true for the modern methods of physical treatment, the author is quite emphatic in his preference for the psychodynamic school of thought. Schizophrenic phenomena are viewed as expressions of "faulty adaptation to the environment" and not as symptoms of "a disease," and the implied synonymity of therapeutic activism and personal interest in the ecological concomitants of mental illness is rather complacent and naïve. Psychogenic and organic theories of schizophrenia are pre-

sented in a strictly dichotomized setting, and the manner in which these and other "contrasting" terms are used (for instance, neurotic-psychotic) seems to presuppose two realms, one physical and one something else, as if man can transcend the biological limitations of his body and has strivings unrelated to the functioning of his organs.

The author appears sincere in his belief that his evaluation of recent progress of research in schizophrenia has been objective. He is certainly correct in stressing the need for promoting sound principles of mental health in combating schizophrenic illness and other mental disorders. However, his concluding statement that by realizing "that for most of us the world never measures up to our initial ambitions . . . a personality thus equipped is the surest defence against the attack of the schizophrenic state" simply confirms the truism that the safest way of escaping a schizophrenic psychosis is that of remaining non-schizophrenic, even though "life is a continuous series of adjustment and readjustment." An equally effective mode of defense might be to enter the world as a grasshopper.

FRANZ J. KALLMANN

PSYCHOLOGY AND ANIMAL BEHAVIOR

THE HERRING GULL'S WORLD. *A Study of the Social Behaviour of Birds.*

By Niko Tinbergen. Collins, London; [Frederick A. Praeger, New York]. $4.00. xvi + 256 pp. + 31 pl.; text ill. 1954.

The modern endeavor to explain animal behavior without recourse either to instinct or to the concept of teleology (not to mention emotion, feelings, race, heredity, or anything short of the environment) is faced with a most fascinating challenge by the ethologist Tinbergen and his colleague, Konrad Lorenz. The particular charm of these men is that while they masterfully restore teleology and instinct to good standing, they are not really old-fashioned. It is precisely that they, too, approach behavioral problems in an ultra-skeptical spirit. The difference is too delightful for words; it is almost ridiculous. The appeal of their work lies not only in its return to common sense, but in the radical way in which they try to account for behavior without admitting that animals can *think*. Surely, their work belongs not to the past, that is, to natural history, but to the same spirit which sees all behavior as environmentally determined. The one thing no naturalist ever thought was that animals rarely if ever think. Needless to say, a strong case can be made for it. As one reads these authors, one finds oneself engaged in a profoundly humorous struggle with an astonishing new extremist position. Tinbergen himself seems equally astonished and in conflict. The fact that animals (and man) *do* think is every now and then apparent to him. But the quantity of the behavior of animals (and man) which can be wholly explained as non-thinking and innate comes to suggest a hopeful clue to problems of behavior, not so much by dividing behavior into that which is instinctive and that which is rational and foresighted, but by presenting an evolutionary picture of what thinking is, and how it arose from what was not thinking at all. The effect is to make the reader as curious as the ethologists are themselves as to the physiological workings of the central nervous system of the lower animals, as though here indeed we are to find the answer to many of our most puzzling questions, and even to achieve the ultimate comprehension of ourselves.

Tinbergen's *The World of the Herring Gull* is a companion piece to his *Social Behavior in Animals*, as well as to Lorenz' *King Solomon's Ring*. It is at once a personal confidence about the pioneer work in ethology and a full and detailed account, magnificently written and developed, of the experimental discoveries of the causes of sea-gull behavior.

H. ANSLEY

THE ABILITIES OF BABIES. *A Study in Mental Measurement.*

By Ruth Griffiths. McGraw-Hill Book Company, New York, Toronto, and London. $6.50. x + 230 pp. + 9 pl.; test ill. 1954.

The author is a British psychologist who has "built up" her own provisional scale of tests based upon studies of mentally handicapped and evacuated normal children. Dr. Griffiths is aware that her schedules, like many others, overlap in detail with those of other workers. However, she states that much in the scale is new, that it is constructed in a somewhat novel manner, and that a new set of standardized apparatus has been made available for applying the tests.

The author expresses her indebtedness to the works of Charlotte Buhler, Arnold Gesell, and others. She has tested over 1,000 babies between 2 weeks and 2 years of age by her method. The book offers no general theories of child psychology, is based on careful observation, takes into account previous methods and tests, and pays special attention to the needs of the handicapped child.

The result is a well-thought-through plan for testing infants. The descriptions of the tests and test situations are described in detail. In some respects the test items are similar to these already described in the Gesell developmental schedules. However, the author points out that "each item has been revised and modified in accordance with the needs of this particular research and the purposes of a standardized scale." There are included a careful description as to how to administer each scale (Locomotor, Personal Social, Hearing and Speech, Eye

and Hand Performance) and a complete inventory of test items (Appendix II). The book also contains an adequate list of references and a comprehensive index.

Students of child behavior have thus been provided with a new, carefully standardized series of intelligence tests for infants. The author deserves praise for a very difficult piece of research which has been brought to a successful conclusion. The book is to be highly recommended.

J. H. CONN

CYBERNETICS. *Circular Causal and Feedback Mechanisms in Biological and Social Systems. Trans. Ninth Macy Conference, March 20–21, 1952, New York.* *Edited by Heinz Von Foerster; assistant editors, Margaret Mead and Hans Lukas Teuber. Josiah Macy, Jr. Foundation, New York.* $4.00. xx + 184 pp. + 2 pl.; text ill. 1953.

This little volume is another of the series sponsored by the Macy Foundation which have done so much to encourage interdisciplinary discussion and thus to foster an oft-neglected phase of scientific thinking and investigation. "All of the members have an interest in certain conceptual models which they consider potentially applicable to problems in many sciences." As a result, the discussions range from The Position of Humor in Human Communication, led by Gregory Bateson, through Central Excitation and Inhibition, (Ralph W. Gerard), and the Mechanical Chess Player (W. Ross Ashby), to Feedback Mechanisms in Cellular Biology (Henry Quastler). It is of great interest (and the group is to be congratulated thereon) to note that mutual understanding has not been blocked by the insistence upon the use of specific technical "lingos"—nor has a new language been developed that would be incomprehensible to the readers in many fields to whom these discussions will provide an invaluable stimulus.

Two primary concepts comprise the basis of the exchange of ideas set forth during this conference: information theory, and the theory of circular causal processes. These theoretical systems are not, of course, entirely independent. What has happened is that certain principles, developed out of the needs of engineering, plus a two-dimensional concept of a circular process (in place of the former one-dimensional cause and effect linkage), have facilitated analysis in divers fields from problems of language structure to homeostasis in the individual and integration in social groups. It is important to remember that one of the relations within the realm of conceptual objects or models is causality. One of the major efforts of scientists must be to obtain "new observations on biological and social systems from an empirical demonstration of the shortcomings of our models."

These discussions will be of interest and value to scientists in every field.

R. G. GRENELL

PERCEPTUALISTIC THEORY OF KNOWLEDGE. *By Peter Fireman. Philosophical Library, New York.* $2.75. xii + 50 pp. 1954.

Of the making of books there is no end, but I am hard put to know why the publishers saw fit to make this particular book. It is not scholarly, nor does it contain any new notions. Such ideas as are stated clearly enough to be understood are merely naive and inconsequential versions of old ones. It is impossible to recommend the book to any group of readers, specialized or otherwise.

JAMES DEESE

RESEARCH METHODS IN THE BEHAVIORAL SCIENCES. *Edited by Leon Festinger and Daniel Katz; 19 contributing authors. The Dryden Press, New York.* $5.90. xii + 660 pp.; ill. 1953.

The last war was responsible for such tremendous advances in the physical sciences that it has been easy to overlook the very substantial advances made in the social and behavioral sciences at about the same time. Actually, the last 15 years have witnessed great strides in the development of methodologies for these sciences, and the reader who gets into this book is almost certain to be impressed by the degree of quantification and rigor which is now possible in these areas.

In this volume Festinger and Katz, with the help of 17 contributing authors, have attempted to survey and codify the research methods currently available to the behavioral scientist. As defined here, however, "behavioral" is too broad a term to apply to the contents of the book. This is more properly concerned with research methods in the "social" sciences. There are 13 chapters with authors and titles as follows: The Sample Survey: a Technique for Social Science Research (A. Angus Campbell and George Katona); Field Studies (Daniel Katz); Experiments in Field Settings (John R. P. French); Laboratory Experiments (Leon Festinger); Selection of the Sample (Leslie Kish); Problems of Objective Observation (Helen Peak); The Use of Documents, Records, Census Materials, and Indices (Robert C. Angell and Ronald Freedman); The Collection of Data by Interviewing (Charles F. Cannell and Robert L. Kahn); Observation of Group Behavior (Roger W. Heyns and Alvin F. Zander); Analysis of Qualitative Material (Dorwin P. Cartwright); Theory and Methods of Social Measurement (Clyde H. Coombs); Distribution-free Statistical Methods and the Concept of Power Efficiency (Keith Smith); and The Utilization of Social Science (Rensis Likert and Ronald Lippitt).

The chapters are rather more uniformly good than is typical of comparable compendia, and several are scholarly treatments of their subject matter. Despite the emphasis on social-science applications, there are also some chapters of general interest, those of Kish, Coombs, and Smith being good examples. All in all this appears to be a book which no social scientist can afford to overlook.

A. CHAPANIS

ANIMALS AND MEN. *Studies in Comparative Psychology.*

By David Katz; a new translation by Hannah Steinberg and Arthur Summerfield. Penguin Books, Melbourne, London, and Baltimore. 50 cents (paper). 192 pp. + 16 pl.; text ill. 1953.

Katz's *Mensch und Tier* was first published in 1937 and revised in 1948. The most notable changes in the 1948 edition involve the addition of material based on the work of the ethologists. The present translation is a rather free version of the 1948 edition. The translation itself is excellent; it carries the spirit of Katz's German without being slavish to it. The translators rearranged much material and added some new material, mostly in the form of footnotes.

The book, from the scientific point of view, suffers somewhat from Katz's tendency to be loose and humanistic. It is certainly as far from the rigorous experimental tradition of American comparative psychology as it can be. This defect, in a sense, is also a virtue, for the book is appealing in a way in which no dull textbook account of comparative psychology could be. If the reader approaches Katz's book in a slightly skeptical frame of mind, he will learn much and probably be entertained as well. Despite its defects, the book can be recommended as supplementary reading for students of biology and psychology. The professional reader will be disappointed to find that the book relies very heavily on the older material, but then a good complete book, of recent vintage, on comparative psychology does not exist.

Penguin Books is indeed to be commended for making such books available to the general public at such ridiculously low prices. In view of the fact that books of such excellence are made so cheaply, perhaps it is unkind to mention the rather poor quality of paper and typography and the elimination of bibliographical references. If these economies are really necessary to the inexpensive production of such books, however, they are certainly worth it.

JAMES DEESE

TWO ESSAYS ON ANALYTICAL PSYCHOLOGY. *Bollingen Series, XX.*

By C. G. Jung. Translated by R. F. C. Hull. Pantheon Books, New York. $3.75. x + 329 pp. 1953.

The Bollingen Foundation has embarked upon an ambitious, if somewhat belated, undertaking in the publication of the *Collected Works* of C. G. Jung, totaling 17 titles in 20 volumes. This book represents Volume 7, although only the second in the projected series. It comprises in a revised form the foundation on which Jung built his system of psychology. In the first essay, The Psychology of the Unconscious, Jung presents his modification of the Libido Theory, marking one of his first important deviations from Freudian thinking. For him the libido became a broad concept, not limited to sexual energy alone but rather embracing all psychic energy. One might appropriately say that Jung desexualized Freud's libido theory.

A description of attitude types, the much popularized introversion and extroversion characters, is attractively illustrated. The remainder of this essay is concerned largely with the elaboration of the very cornerstone of "analytical psychology," namely, the theory of the Collective Unconscious with its archetypes and primordial images; the implications for his "constructive" or "synthetic" method of psychotherapy are also drawn. For Jung there is a personal psyche and a transpersonal or collective psyche, and it is in the failure of the other "schools" to understand and explore this latter unconscious region that he sees the limitation and fallacy of their therapeutic approaches. The methods of Freud and Adler he lumps together as purely reductive and causal. What is needed is a "synthetic" or "constructive" conception, and this is not possible without due consideration of the collective unconscious.

The concept of "persona" as a segment of the collective psyche is described in dramatic language. The persona is a mask worn by each individual showing him as he thinks he is and generally acceptable to society, but not what he really is.

The second essay deals with The Relation between the Ego and the Unconscious. All psychic disease is seen by Jung as the failure or inability properly to assimilate the unconscious. The conscious and unconscious are not necessarily antithetical; in fact they are compensatory and complementary. One must delve into vast treasures of primordial images to integrate them into the total personality.

In striving to free the individual from his neurosis one may resort to a "regressive reduction of the persona" or one may achieve an "identification with the collective psyche." But both of these methods are negative and at best result in coming to terms with the illness, on a lower level. To really liberate the individual, to achieve a genuine "individuation," the "constructive" method alone suffices. The goal of analysis is the "transcendent function," that change which results from a true "differentiation between the ego and the figures of the unconscious."

The metaphysical concept of the "anima" and "animus," apparently standing for the "soul" of the psychic, is described in vivid if not exactly scientific language. The idea of a "manna-personality" is also introduced. Jung frequently goes far afield to touch on many sociological, philosophical, and spiritual aspects of his psychological concepts. These digressions are as interesting as they are thought-provoking. Space does not permit more than a mere mention of the principal themes discussed in the volume.

Being in no position to evaluate Jungian psychology critically, I can only record my "lay" impressions. The interested reader is referred to the study by Patrick Mullahy (*Oedipus: Myth and Complex*) and to Edward Glover's more penetrating analysis in his book, *Freud or Jung*. The Freudian will find himself in opposition to Jung's concepts of mental structure, function, and dynamics as well as the system of therapy that flows from these ideas. The eclectic psychologist will discover much comfort in Jung: concepts which he can add to his own arsenal, and sharp criticism of Freud with which to buttress his own objections. Whether one agrees or not with these Jungian constructs (and there are few who do), these ideas are presented in so interesting and provocative a manner and are written in such a compelling literary style that a reading of these chapters proves an exciting and stimulating experience.

MEYER STEINBACH

PSYCHOLOGICAL REFLECTIONS. *An Anthology of the Writings of C. G. Jung. Bollingen Series, XXXI. Selected and edited by Jolande Jacobi. Pantheon Books, New York.* $4.50. xxvii + 342 pp. 1953.

This book is a translation of a compilation of over a thousand quotations culled from the 60 published works of C. G. Jung, first issued in 1945 on the occasion of his 70th birthday. Jolande Jacobi, the foremost European disciple of Jung, gathered this "anthology" by selecting not his technical writing but rather "the characteristic statements of a more general nature" which present Jung's thinking. She cautions against seeing these selections as "moralizing precepts, prescriptions or warnings," and indicates that Jung's "urgent purpose is to lead people to a responsible attitude toward life and a responsible way of living, suitable to the individual peculiarities of each man." While the editor has been quite successful in choosing statements widely representative of Jung's prodigious contributions, her injunction against regarding these selections as "moralizing precepts," etc., is not very convincing. These quotations have a predominantly epigrammatic, aphoristic, and evangelical quality. This is not to gainsay or minimize the attractiveness or power of Jung's writing. On the contrary, few in the field of psychology or even related disciplines can express themselves with such feeling and rhetoric or can coin phrases of such sententious meaning and poetic beauty. These are truly the productions of a creative artist.

This volume (one of a projected series of Jung's published works) is divided into the following general sections: Recognition of the Psyche, Man in His Relation to Others, The World of Values, On Ultimate Things. Subsections deal with such topics as Recognition of the Soul, Consciousness and Unconsciousness, The Primordial Images, Dreams, Doctor and Patient, Man and Woman, Youth and Age, Awareness and Creative Living, Between Good and Evil, Life of the Spirit, Western and Eastern Points of View, Fate, Death and Renewal, or The Way to God.

However well Jung may have succeeded in writing provocatively and engagingly on a wide variety of psychological, ethical, religious, philosophical, sociological, and metaphysical subjects, these observations and pronouncements scarcely add up to a convincing body of scientific thinking; and it is perhaps little wonder that although indefatigable in his efforts for over 50 years, and though publishing more than any other psychologist living or dead, C. G. Jung's misguided genius has fallen on rather barren soil. Although Jung himself had faith in posthumous recognition, it is highly doubtful that at this late date the world of scientific psychology and psychiatry will accord him any greater acceptance. For Jung's "analytical psychology" is largely an amalgam of pre-Freudian conscious psychology, oriental mysticism and derivatives of alchemical and animistic thinking, dressed in such Jungian terminology as persona, shadow, collective unconscious, anima and animus, individuation, transcendent function, élan vital, laws of opposites and compensation, etc. It is unfortunate that his vast erudition in the fields of classic literature and language, mythology, anthropology, philosophy and religion, aided him so little in the creation of a scientific psychology. Nevertheless, many of Jung's ideas will probably prove attractive to the casual reader and eclectic psychologist, especially to those who need to replenish or fortify their criticism of Freud. Many persons in search of a mystical or metaphysical solution to the burning problems of our mundane existence may find here some spiritual appeasement. To the creative writer there may be considerable appeal in these writings. But it is difficult to imagine what the various scientific schools of psychologic thinking, extant in this country, can currently learn from C. G. Jung.

MEYER STEINBACH

PSYCHISCHE KOMPONENTEN DER SINNESORGANE. *Eine psychophysische Hypothese. By Bernard Rensch. Georg Thieme Verlag, Stuttgart.* DM 22.50 (paper). ii + 200 pp.; ill. 1952.

The author is basically concerned with the localization of psychophysical processes in the organism—i.e., with the location of the mind. To say the least, he is not unique in being intrigued by this problem. Nor is he unique in not being able to keep to himself his fantasies derived from inadequate integration of, for the most part, perfectly adequate empirical data. His thinking is neither biologically accurate nor philosophically logical. Professor Rensch, it appears, has been subjected to the temptation of St. Anthony and has had the misfortune to come through his trial completely scathed. He has fallen into the trap so many of us conscientiously try to avoid—a trap that smells as bad by one name as by another—the fallacious differentiation of the brain and mind, mind and matter, mind and body, or what you will. Let us look, for a moment, at his hypothesis.

The author's self-termed aesthetophysical hypothesis is based on several points, including: sensations and "imaginations" run parallel, not to processes in the cortex, but to processes in the sense-cells of the receptors or sense-organs; the neurons of the brain only have the function of associating sensations and imaginations in a manifold manner by conduction of stimuli and by bringing about the connections of consciousness of self; acts of volition do not need a special psychophysical substrate; with regard to the psychic processes, the phylogeny of the animal kingdom up to man is to be looked at as an increasing complexity of the connections of consciousness—an increasing complexity of the central nervous system; fixed mutual relations of psychic components only exist within the same connection of consciousness. Coincident and identical psychic components in two equivalent sense organs fuse and become one. The spatial components especially may fuse.

In summary, the theory states that "... we are perceiving and imaging 'with' the brain 'in' the sense organs. This aesthetophysical hypothesis eliminates the dualism between the two basic categories of phenomena, the sensations and the imaginations." The majority of the book is an attempt to construct and support this thesis by suggesting that numerous 'facts' of the theory of cognition, of neurophysiology, of pathology, and of zoology, if blended in the proper proportions, will predict when 'Birnham wood to high Dunsinane hill shall come.'

Criticism of this theory in detail and in the proper documented fashion would result in a paper of far too great extent for its place as a book review. Only a few of the simpler, more obvious problems can be touched upon as examples of how dangerous the intellectual life can be. Rensch professes (as one of the bases of his thesis) that "most sensations are *experienced* locally in the sense-organs." How can he think of 'experience' in this narrow way? Sense-organs are merely the information-getting and transmitting part of a feedback system. The experience of the organism, briefly, is the totality and interplay of stimulus reception, transmission, integration, interpretation, and response. Experience and reception of a stimulus are not equivalent.

The author also gives the impression that he is not quite clear about some of the more recent concepts of organization of the brain and structure of central nervous system neurons. He has not taken into account the evidence for shifting certain levels of functional activity from the cortex to so-called lower levels of the central nervous system; nor is he fully aware of the not inconsiderable differences between groups of cells in the various areas of the brain.

One has the feeling that the author—obviously extremely widely read—could have put together a much more watertight story if he had considered the data in a somewhat different way; if, of course, he insists on putting the story together in the present state of our ignorance.

It is a soothing balm to the scientist that Prof. Rensch defines his position regarding the problem "as a philosopher, not as a biologist, for a biologist would not advance a hypothesis passing so far beyond his special field."

R. G. GRENELL

HUMAN BIOLOGY

UNITED NATIONS DEMOGRAPHIC YEARBOOK 1952. *Fourth Issue.*

Statistical Office of the United Nations Department of Economic Affairs, New York; [*Columbia University Press, New York*]. $7.50 (cloth); $6.00 (paper). 518 pp.; ill. 1953.

This issue of the *Demographic Yearbook*, besides carrying on the basic tables of preceding issues, has extended the vital statistics series back to 1920 instead of stopping at 1930. New tables include statistics of the resettlement of refugees and crude divorce rates. A number of qualitative improvements have been added. The opening article surveys urban trends and characteristics throughout the world. It includes brief sections on urban fertility and mortality which will be of interest to students of public health.

E. F. PENROSE

THE LIMITS OF THE EARTH.

By Fairfield Osborn. Little, Brown & Company, Boston. $3.50. x + 238 pp. 1953.

This is a thought-provoking book, concerning the relationships between the population of the earth and the limited and constantly consumed mineral and other non-renewable resources of the earth. The living or renewable resources can be increased some-

what. The failures of cultures have moved westward from central Asia and along the Mediterranean. Mounting populations in many countries, largely as the result of the applications of medical and public health measures, result in more people not getting enough to eat, particularly in Asia. The remaining resources of Australia, New Zealand, Canada, Argentina, and the United States are also limited; their own populations, increasing at the present rates will, in a few decades, tax their resources severely. While tropical Africa is still under-developed, South Africa is faced with dilemmas arising from the diverse racial and cultural backgrounds of the inhabitants.

The Iberians enforced feudalism in their colonies; it still curses the resulting cultures. Exemplifying this, the Amazon is dealt with realistically, its severe limitations as a region even for subsistence food production are emphasized; as a region for extensive settlement it offers amazingly little. Finally, when the limits of the other resources of the earth, such as water and food from the sea, have been considered, they offer very little scope for meeting man's increased needs. We see that while the earth has continued to support and feed, after a fashion, a continually increasing number, mankind must decide upon some measures for the limitation of numbers, or we shall have declining quality and lowered standards of living for all.

ROBERT L. PENDLETON

THEORETICAL ANTHROPOLOGY.

By David Bidney. Columbia University Press, New York. $8.50. xiv + 506 pp. 1953.

Being scientists, most anthropologists have so far operated with certain philosophical premises (i.e., idealistic or materialistic ones), without being very conscious or critical of them. For their benefit a professional philosopher, D. Bidney, dissects here with great scholarship their theories of cultural reality and the nature of man, and finds them all wanting. His own concept is "polar" (nature and culture are interdependent), and "humanistic." On account of the existence of free will, culture cannot be studied with the same outcome as nature. He then proceeds with the same admirable scholarship and critical ability to a most interesting analysis of the different theories of cultural dynamics from evolutionism to functionalism. The other half of the book is devoted to discussions of theories of myth, personality, cultural crisis, integration, and values. This book is not a systematic analysis of all anthropological theories, as some might erroneously deduce from the title, but of such anthropological theories as are accessible to the metaphysician. Within these limits it is an impressive, timely, and useful contribution.

ERWIN H. ACKERKNECHT

METHOD AND PERSPECTIVE IN ANTHROPOLOGY. *Papers in honor of Wilson D. Wallis.*

Edited by Robert F. Spencer. The University of Minnesota Press, Minneapolis. $4.50. xii + 323 pp. + 1 pl. 1954.

This is a successful attempt to avoid some of the shortcomings of the species "Festschrift." The 12 papers composing the book have at least a common denominator, and are all discussed in a final article by Alfred L. Kroeber, the universally admired dean of American anthropologists. They are authored by some of the best known American anthropologists, like M. J. Herskovits and the late R. Linton. The contributions of younger and not yet so universally known men, such as J. H. Greenberg, the editor R. F. Spencer, or Omar C. Stewart, are no less valuable. This is a substantial addition to the small body of theoretical literature in anthropology.

ERWIN H. ACKERKNECHT

ASPECTS OF CULTURE AND PERSONALITY. *A Symposium.*

Edited by Francis L. K. Hsu. Abelard-Schuman, New York. $4.00. xiv + 305 pp. 1954.

Another symposium destined to bring together anthropologists, psychologists, sociologists, and psychiatrists. There is not much of a visible internal connection between the 10 short papers composing the volume, nor do the chatty discussions help much in this direction. As none of the papers rises above the level of an average journal article, one wonders why they had to be preserved in this form.

ERWIN H. ACKERKNECHT

THE HUMAN ANIMAL.

By Weston La Barre. The University of Chicago Press, Chicago. $6.00. xvi + 372 pp.; ill. 1954.

This is an attempt to unify the biology and sociology of man. Evolution in general, that of the primates, and of man are reviewed for this purpose. With the development of the human hand a new kind of evolution, outside the body and technological in nature, enters the scene. Heightening of two mammalian functions, infantile dependency and sex, brings about, according to the author, the human family, the creation, and the difficulties of culture. Human culture deals with reality via symbols, of which the linguistic ones receive particular attention.

The author brings together an imposing number of interesting facts and good ideas, old and new. Yet I feel that, just like his predecessors, he has not reached his goal. Human biology and evolution explain to a certain extent "culture," but not cultures, the actual objects of the social sciences. The author's biological reasoning is seriously marred by a somewhat exuberant

teleology (another form of animism, to apply his own terminology). His sociological reasoning is entirely psychoanalytical, that is, largely mythological, lacking proof, and leading to such absurdities as the equalizing of culture and psychosis. The book could be called well written, if the author did not labor under a permanent compulsion to be "cute." But this seems rather popular at present.

ERWIN H. ACKERKNECHT

SUICIDE AND HOMICIDE. *Some Economic, Sociological and Psychological Aspects of Aggression.*

By Andrew F. Henry and James F. Short, Jr. The Free Press, Glencoe, Ill. $4.00. 214 pp.; ill. 1954.

This could have been an important book. Not only is its theme—the vicissitudes of aggression and their sources—a valid research question that has persistently evaded solution because of its great complexity; but more than this, numerous social, philosophical, and even political implications are involved. Unhappily, however, the authors have been content merely to confine their work to a fairly careful sociological investigation. What they have produced, therefore, is more like a doctoral dissertation and is hardly a suitable volume for general publication under so resounding a title. That this criticism is deserved is revealed by the fact that of 214 pages, 50 are occupied by five appendices, 13 by notes, 8 are taken up with bibliography, and 7 include the index. In the remaining 94, certain hypotheses are raised regarding both suicide and homicide. These hypotheses are then tested by standard techniques within a research population for partial or complete substantiation; and are discussed, finally, relative to existing social, economic, and psychological theory. Such conclusions as emerge are left to be developed further by the reader within the context of his own choice, or, perhaps, by the writers in future monographs they intend to write.

ROBERT LINDNER

BIOLOGIE DES RACES HUMAINES. *Collection Armand Colin (Section de Biologie), No. 275.*

By J. Millot. Librairie Armand Colin, Paris. 260 fr. (paper). 224 pp. 1952.

The author of this smallish book of a little over 200 pages wrote some years ago, together with Lester, a similar work entitled *Races Humaines*, the second half of which was devoted to the comparative physiology of human races. It is this physiological section that Millot has now revised, expanded, and brought up to date. The present book is divided into three parts: the first concerned with variation, growth and development, fertility, and race mixture; the second with physiology; and the third with pathology.

The most useful sections are the second and third, since it is here that the author has brought together in an easily accessible form data that are rather widely scattered. The physiological evidence covers the blood, metabolism, regulation of body temperature, the nervous system, sense organs, endocrine system, respiratory, circulatory, and muscular systems.

The pathology section deals mainly with diseases and is relatively brief. In both comparative physiology and pathology, the difficulties of segregating the effects of environment from those of race are fully appreciated and the author makes an effort to preserve a critical attitude before the evidence, which is too frequently equivocal. On the whole he succeeds in this, although some readers might disagree with him on specific points. Unfortunately, much of the data is poor for the purpose, through no fault of the author. In some instances the author, however, has overlooked better evidence than he presents. On the whole, this is a useful book.

HARRY L. SHAPIRO

CLIMATE & ARCHITECTURE. *Progressive Architecture Book.*

By Jeffrey Ellis Aronin. Reinhold Publishing Corporation, New York. $12.50. x + 304 pp.; ill. 1953.

Nearly three hundred illustrations, of which half are photographs of very high quality, and a striking layout make this a most impressive book. It is clear, from the catholic scope of the diagrams and the innumerable quotations, that the author has read very widely, and has gathered unto him the broad acquaintance with architectural form, environmental conditions, and representational method which is essential for the good practice of the art. Those who are interested in picking up stimulating ideas or promising methods in relating design to environment will find many a lead herein. But beyond these attractive and necessary features there is something missing. The biologist will be disappointed, since, except for a particularized list of some suitable vines and trees, living things are scarcely mentioned, and man himself is either ignored or taken for granted. Man may not be the sole proper study of mankind, but he is surely the reason for architecture; and it is difficult to see how the significance of climate for architecture can be adequately discussed without some consideration of the effect of climatic conditions upon man, and of the amelioration that housing design might afford. The author has advanced the cause of the rational in architecture by insistence upon a simultaneous consideration of form and function; but he has not gone far enough in his concept of function. In other respects, also, he has stopped short of a thorough and mature work, by too heavy a reliance upon the view of others. The presentation would have

been more effective and convincing if he had enunciated the basic principles as he sees them, and reserved quotations to a well-selected few, with simple credits to sources of information. The facade is brilliant, but the author has not made it easy to inspect the foundations.

DOUGLAS H. K. LEE

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

LABORATORY INSTRUMENTS. *Their Design and Application.*

By A. Elliott and J. Home Dickson. Chemical Publishing Company, New York. $7.50. 414 pp. 1953.

To those who have the ability, when conditions beckon them, to design and construct their own instruments, this book will be of great value. It deals with such techniques as: The Accuracy Attainable in Machining Operations; Properties of Materials used for General Construction of Instruments; Casting and Jointing of Metals; Preparation of Drawings; Constrained Motion and Constraints; Magnification of Small Displacements; Sensitivity and Errors of Instruments; Isolation of Apparatus from Disturbing Influences; Damping; Tests for Straightness, Flatness and Squareness; Glass; The Working of Glass; Lenses, Mirrors and Prisms; Optical Instruments; and Photography in Research. It definitely belongs in all university libraries.

DAVID B. TYLER

PRINCIPLES OF COLOR PHOTOGRAPHY.

By Ralph M. Evans, W. T. Hanson, Jr., and W. Lyle Brewer; Eastman Kodak Company. John Wiley & Sons, New York; Chapman & Hall, London. $11.00. xii + 709 pp.; ill. 1953.

Principles of Color Photography entailed a prodigious amount of work during its preparation. In order to provide a background for the reader to understand the special problems encountered in the process of photograph color reproduction, experimental and theoretical considerations from biology, chemistry, and physics were integrated into a reasonably comprehensible whole. The book begins by considering the response of the eye, a biological system, to light in simple fields. The problems of color matching, the diffusion of colors, and the objective description of color sensations are discussed. This introduction, of course, is prerequisite to an understanding of the chemical and physical problem of producing an acceptable color image of an object photographically. The second chapter of the book is concerned with the specifications of color and its measurement, and is followed by a comparative discussion of black-and-white responses and of responses to colored objects. The problems involved in producing a color image are then considered. There follows a long series of technical chapters on the wavelength sensitivity of various emulsions, the physics of development, and the formation of color images following or during development. There are additional sections on the history of the various types of color photographic systems, the types of dyes and colorants used, the optical characteristics of colorants in combination, the technical measurements of absorption density, and numerous other special problems. The chapter which appealed most to me was the one describing different color photographic systems. Most color reproduction methods have depended upon the formation of separate images on separate layers of photographic material, each layer having a certain wave-length sensitivity. After exposure the images are developed, and dye stuffs are either added or subtracted from the various layers. Other systems in less common use involve special optical tricks for separating in a single plane the various color images. Of particular interest was the lenticular process, which has since been discontinued. In this process a single lens was used, and different portions of the lens were covered with three different color filters. The portions of the images which corresponded to transmission through each of the filters were focused by means of separate lenses built into the film onto areas sensitive respectively to one or another color. Positive development, followed by projection through an identical system operated in reverse, resulted in a projected color image. Another method discussed in some detail involved the exposure of a film or plate containing separate particulate dyed elements sensitive to light of different colors. When these are exposed, and then subjected to a reversal process, the picture shows up and is viewed through the same particulate filters which were used to make the exposure. One of the most interesting processes, and one which is no longer in general use, is the so-called Lippmann-type photograph. In this process use is made of the fact that light reflected from a shiny surface exhibits maxima and minima in the standing wave extending back from the surface. At the nodes there is no exposure of the film; at the internodes there is a maximal exposure. Since the spacing between the nodes or internodes is a function of the wave-length one obtains, for example, a wide spacing for red light, and a narrow spacing for blue light between the internodes. When such a film is developed and the picture is viewed from the original light axis, the image is seen to stand out in color without the use of any dyestuff. The reflecting material used in this process has generally been mercury, which is placed against the back of the emulsion. Upon viewing, a black absorbing material must be placed behind the film to prevent reflection from the rear surface. Unfortunately there are several disadvantages to this, in principle, simple

process. One is that the pictures must be viewed from a rather narrow range of angles, as otherwise considerable color distortion results. Secondly, because of the fine grain which is required in order to obtain good images, the process is extremely slow. And finally, the process is extremely sensitive to developmental effects.

This book appears to be an excellent addition to any reference library on photographic processes, and is also a welcome addition to the amateur photographer's shelf, if his interests include the nature of the processes employed as well as his own technical proficiency.

BERNARD L. STREHLER

SYMPOSIUM ON LIGHT MICROSCOPY. *Presented at the Fifty-Sixth Annual Meeting (Fiftieth Anniversary Meeting), American Society For Testing Materials, New York, N. Y., June 25, 1952. ASTM Spec. Pub. No. 143.*

American Society For Testing Materials, Philadelphia. $2.50 (paper). iv + 126 pp.; ill. 1953.

The title of this paper-bound volume might be somewhat misleading, for while the biologist may find much of value in three of the papers which deal with the theory and tools of microscopy, the remainder of the volume is devoted to a consideration of the application of microscopy to problems of engineering. The topics covered include textiles, concrete, metals, resins and their plastics, and particle-size analysis, together with a discussion of the problems peculiar to each field.

C. P. SWANSON

RECURRENT MALADIES IN SCHOLARLY WRITING. *By Eugene S. McCartney. University of Michigan Press, Ann Arbor.* $2.50. xiv + 142 pp.; ill. 1953.

This absorbing little book, which deals, as its name indicates, with problems facing the writer of scholarly articles, should do much to improve the style and lucidity of contemporary scientific writing. This statement, of course, presupposes that scientists and scholars will take the time to read the volume, and that they, unlike the reviewer, are not hardened in their literary habits. The chapters in this amusing little book were originally—starting in 1938—published in the *Michigan Alumnus Quarterly Review*. The author takes writers, and scholarly writers in particular, to task on a number of counts. Only a few of his indictments will be reviewed here so that the reader may not suffer and the writer not be embarrassed. The first chapter deals with the question of the studied avoidance of simplicity. The chief point at issue in this particular portion of the text seems to reside in the domain of excessive verbiage when employed for the purpose of purveying relatively less complicated concepts. The author allows his ire to be felt by the volume peruser on such unforgivable manipulations of the script as the preceding sentences exemplify. The next chapter, which is more difficult to evaluate, argues for the use of simple and pleasant sounding words, if they express the thought as well as more complicated ones. An amusing chapter on illogicality follows in which the author literally points his accusing finger from the pages of his book. His examples range from "A cargo ranging from succulent Spanish olives to sporty English convertibles" to "They sell everything from hardware to hard candy." The author maintains that it is a fact that one probably very seldom sees cautious wording like this: "The charges are shot through with inaccurate statements of fact." Nor does one often find an attitude so discreet as that of a man "who did not question any of the facts."

Being one of the most amusing parts of the book, I also found the chapter on Some Participles I Have Met the most enjoyable, and one which, being eager to improve, I have also learned the most from. Examples: "Being a clergyman, and more or less sedentary in my habits, obesity crept upon me unawares." "Dried out for lack of moisture, the rain will restore the mushrooms to their original shape." "While laughing at this, the fish got away." And, "When the beetles are disturbed in swimming about, the oxygen need is much greater."

Being considerate of the reader the book will not be reviewed further. I feel, as an amateur writer, the author has done me a great service which my future writing will reflect.

BERNARD L. STREHLER

THE QUARTERLY REVIEW OF BIOLOGY publishes critical reviews of recent researches in all of the special fields of biological science. The contribution should present a synthesis or digest of the researches and a critical evaluation of them. A mere synopsis of the literature without evaluation or synthesis is not desirable.

Theoretical papers are published occasionally, especially when such papers (1) include a critical synthesis of the literature bearing on the theory and (2) are likely to promote further research in a given field.

The article should be written in concise language, yet in sufficiently non-technical form as to be intelligible not only to specialists in other fields but to the general biologist as well. To this end the article should have a general introduction and a summary which enumerates one by one all of the principal facts and conclusions given in the paper. Interpretative diagrams and schemes are very desirable.

Material ordinarily taking the form of footnotes is set in small print and placed in the text and consequently should be written in a style so as to fit readily into the text. Acknowledgments are printed in the text in small type at the end of the article just preceding the List of Literature. Recent issues of the Quarterly should be examined for style as regards (1) section or subsection headings in the text, (2) literature citations in the text, and (3) List of Literature.

The subjects and authors of articles are selected by the Editors and members of the Advisory Board. Unsolicited articles which conform with the objectives of the Quarterly will be considered for publication.

A feature of the REVIEW is the section dealing with *New Biological Books*. In this department the book literature of different countries in the field of Biology is given prompt notice.

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CONTENTS

Background Adaptations
—*George Howard Parker* (105–115)

The Comparative Pharmacology of the Suprarenal Medulla
—*G. B. West* (116–137)

Physiology and Phylogeny in the Water Molds—A Reevaluation
—*Edward G. Cantino* (138–149)

New Biological Books
Reviews and Brief Notices (150–206)